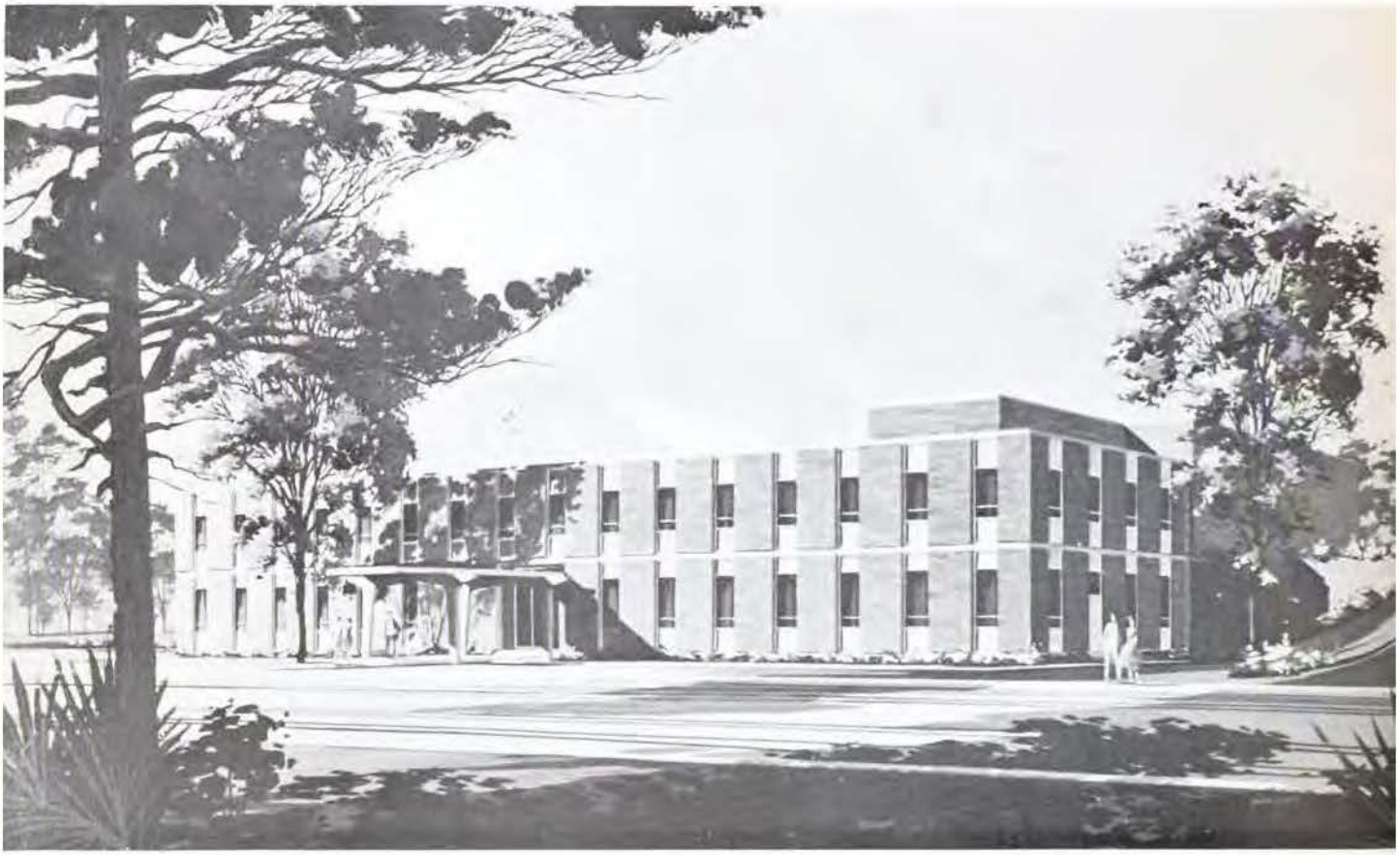
REPORT

FOR

1961

Southeastern Forest Experiment Station
Asheville, North Carolina

U.S. Department of Agriculture - Forest Service



Architect's rendering of U. S. Forest Service research laboratory to be built on the University of Georgia campus at Athens. Construction will begin in the summer of 1962. The plan provides offices and laboratories for some 20 Station researchers and their assistants.

Cover photo: Seed orchard of grafted slash pine in Georgia

1961 at the Southeastern Forest Experiment Station

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FOREWORD

The forest research job goes beyond developing ideas, proving them, and adding to knowledge. The work is not complete until results are made available to scientists, practicing professionals, and others. Hence, as the Station grows, our informational activities multiply.

On checking into the information job, we find that during the last 5 years our researchers have published nearly 600 papers and articles in technical journals, Station Papers, Research Notes, USDA bulletins and the like.

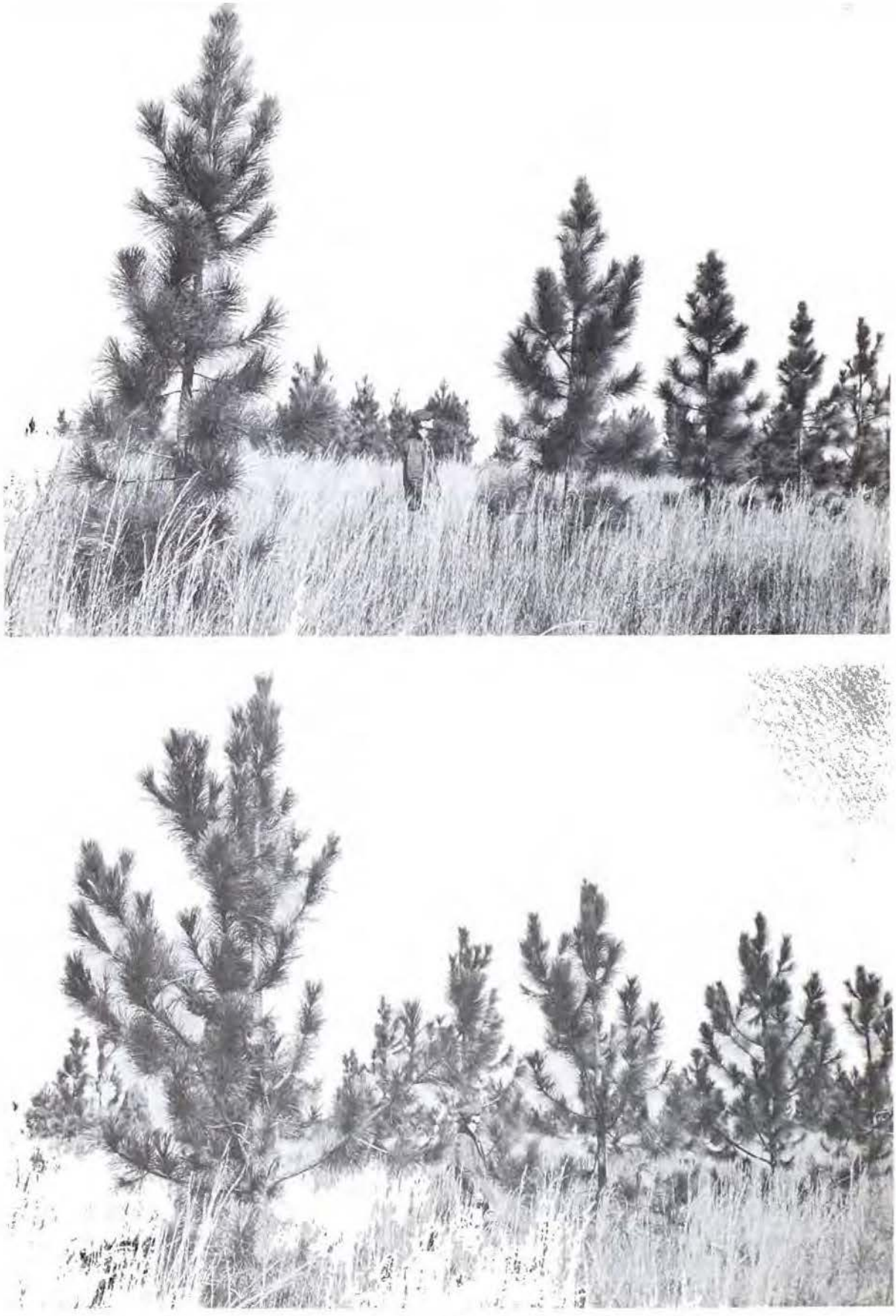
In the past year we have issued 133 publications, as shown in the list at the end of this report. These run a wide range from highly specialized papers at one extreme to writeups for landowners and the general public at the other. During this same period we distributed some 133,000 copies of recent or past publications to our address list, which is mainly composed of foresters from all 50 states, plus 150 foreign forestry specialists many of whom have visited us at one time or another. A number of these reports are quoted and excerpted by others or find their way into textbooks. Thus, dissemination of research results does not stop with the original publication but sometimes is only the beginning.

Word-of-mouth is perhaps as important as print for spreading forestry information. Year's end tally shows the Station and its field centers received over a thousand visitors requesting information. We organized guided tours of experimental forests for 3,000 people (most of whom are in forestry as a business, profession, or way of life) and gave slide lectures, talks, movie showings or presentations of papers to a total audience of 13,000.

Our men also put on 17 forestry exhibits, answered 2,300 letters asking advice, and sent out 38 newspaper items.

First comes research, the seeking for answers and new knowledge. With this must go the "climate" for creative work, and the constant search for well-trained men with original minds. Second comes the issuing of research results. As forest practice intensifies, more people are asking more questions. We are trying hard to give them more answers.

JOSEPH F. PECHANEC, Director



Slash pine grafted trees at Allentown, Georgia. Narrow-crowned clone at top; wide-crowned clone at bottom.

FOREST MANAGEMENT

TREE IMPROVEMENT

THE BROAD PICTURE

Forest tree improvement in the South has a long way to go, but it has made great strides. Tree breeders have been working at the job of increasing production by bringing in more valuable species, by using seed of the fastest growing native races as well as individual trees of the best races, and by selective breeding to create still more valuable strains. All this cannot be done in just one study but must come from many studies and sustained effort that follows a clearcut pattern for a long period.

In the 1920's, tests of important tree species from foreign countries and the western United States were begun in western North Carolina. During the 1930's, tests of introduced species continued and a few progeny tests were started which later failed because of adverse conditions. In 1941, racial variation studies were started on the Lee Experimental Forest in Virginia.

In that same year, the Lake City, Florida, staff began the first systematic scouting of the naval stores belt for naturally superior trees. The researchers were looking principally for good-form slash pines that produced exceptional yields of oleoresin. They did not know how much natural variation existed in the southern pine species, though later work demonstrated more than they had dreamed. They did not know whether superior gum producers would reproduce this trait in their progeny. There was a dearth of information on inheritance of traits and what environmental factors were important. It was commonly thought that environmental factors were responsible for the wide differences observed between trees in natural stands and plantations. There was little to guide tree breeders in techniques of obtaining rooted cuttings, in control pollinating, progeny testing, or seed orchard establishment.

The general feeling in forestry circles was that it would take a lifetime to mass produce superior strains of southern pines, and that disease could wipe out the selected clones at any time. The Lake City researchers consequently felt a sense of urgency that resembled Andrew Marvell's lines:

But at my back I always hear
Time's winged chariot hurrying near;

From the start, they tried to double up processes and make simultaneous tests. For example, while one was scouting thousands of square miles of pineywoods in north Florida and south Georgia for superior gum yielders, others were at work in the greenhouses and laboratory on grafting and rooting techniques that would reproduce the actual germ-plasm of elite trees and prove or disprove the inheritance of superior traits.

The scout found trees producing two or three times more gum than average trees of the same age in the same stand. In his travels through the forest, occasionally meeting a solitary turpentine worker, he also noted trees exceptionally taller, straighter, less limby, and much faster-growing. He took hundreds of increment-borer cores to prove that neighboring trees were the same age as this taller, thicker, straighter one. He soon ceased to bother with trees that were a little better, looking only for individuals that were dramatically superior, winnowing out some of those as he found specimens even better. He made the standards more and more ruthless, and at last had 20 trees that satisfied him. Now to progeny-test them, to plant a twig and find to what extent the traits were duplicated in the young tree and to preserve the original wild stock. This would be a different thing from the wind-pollinated forest tree, whose inheritance pattern is obscured by the fact that one parent is unknown.

But tests weren't going too well at the lab. In thousands of cuttings from mature slash pine, none rooted or even calloused, and all eventually died. It was only after a year of patient effort, after 175 different hormone and vitamin treatments set out in 40 different environments in winter, spring, and summer plantings, that one solitary twig finally put out roots and survived. From this they learned how to do it, and worked with additional thousands of cuttings in greenhouses watered by clockwork and watched over night and day. Here was produced material for a small plantation, a plantation unique in the world, with a few cuttings from each study tree that would prove which mother trees were best. And they could breed from those, and then later on when they were growing the best that nature afforded, maybe they could cross superior trees and produce something better than had ever grown wild.

And so the plantation was set out at Lake City. (It is now 16 years old and 40 feet high, and crosses have been made, and a plantation of those set out.)

The scene soon moved to Georgia. Interest was picking up. In 1949 the Station arranged a cooperative project in applied forest tree breeding with the Ida Cason Callaway Foundation, of Pine Mountain. The Foundation's primary objective was to make available in west Georgia improved types of forest trees for commercial planting. Mr. Callaway was not so much interested in the best possible tree in 100 years as in achieving something moderately better in 10. Station researchers selected superior individual trees for growth rate, crown type, form, vigor, wood quality, disease resistance, ability to provide abundant seed, and other characteristics. They found trees growing 2½ times faster than companion trees of the same age in the same stand. Selection and reselection, nursery testing, outplanting, progeny testing, hybridization all went forward simultaneously. Wind-pollinated and control-pollinated seed from outstanding individuals of the major southern pine species were used to establish more than 80 acres of progeny tests. At 3 years of age, seedlings were evaluated as parent stock. The work progressed with such rapidity that the Foundation began establishing seed orchards in March of 1955. The trees themselves demonstrated with increasing clarity that some superior individuals should be retained as breeding stock because they transmit superior traits to their progeny, whereas others should be discarded because they do not.

The selected trees on the Callaway properties still appear to be outstanding on the basis of another examination at 8 years. The first seed will probably be produced by the seed orchard within the next two or three years. In addition, the test plantations have provided data and wood samples for numerous studies by colleges and universities on variation and inheritance in pines. Thus, in the span of 10 years, plus trees were selected, progeny tested, and in a few years more a seed orchard there will have been brought to the point of production.

On the Callaway project at present, records of over 200 selections of the 4 major species of southern pines are kept. A continuous record of more than 27,000 seedlings is maintained.

Since the production of quality tree seed in commercial quantity at the earliest possible date is one of the most urgent needs in southern forestry, the Callaway Tree Improvement Project was watched with intense interest. The project demonstrated that important gains in tree improvement can be achieved and rapid progress made through extensive genetic improvement without sacrificing sound but slower basic approaches.

In 1951, the Station helped the Southern Station to establish the now-famous Southwide Pine Seed Source Study by arranging cooperation for seed collection and planting in the southeastern states. This work is of great importance in showing what and how much racial and geographic variation exists, and in providing performance tests that demonstrate the suitability of each strain for planting in each geographic area. Strain improvement progresses fastest if done in locations where the strain is to be used, so it can be tested against diseases, insect pests, soil and other site conditions, maximum and minimum temperatures, wind, snow, ice damage, or any combination.

When the southern pine planting program mushroomed to hundreds of millions of seedlings per year (now a billion-and-a-quarter seedlings produced annually in 60 nurseries), it became apparent that seed collectors on a wide scale were gathering cones from bushy, runty, easy-to-climb trees. The Callaway Project had demonstrated that limby, undesirable trees produce undesirable progeny. The expanded planting program was in danger of degrading the race. Consequently, the need was inescapable to produce and plant superior stock, rather than run-of-the-mill seedlings concerning whose heredity nothing was known.

Georgia was starting the biggest planting program of any state in the union. One of the aims was 500 acres of seed orchards. For this reason, at Macon, Georgia, in 1954, the Forest Service began cooperative work requested by the Georgia Forestry Commission and the Georgia Forest Research Council in the improvement of genetic tree seed quality and forest tree seed production for the State nurseries. Since then the Station has developed a comprehensive plan for the Georgia project, helped the Commission establish several hundred acres of grafted seed orchards, established progeny tests with control-pollinated stock of seed orchard clones, helped develop a seed certification program, established a statewide study of racial selection in loblolly pine, worked out an estimate of the influence of mother trees in racial studies, started a test with several hundred super seedlings selected for rapid growth in nursery beds, made numerous selections of outstanding trees of the four major species of southern pines and control bred them for combinations of superior traits, established observation plots of plantings of the minor southern pines to determine growth performance and resistance to pests, provided the Southern Institute of Forest Genetics with stock indicating some resistance to fusiform rust, worked with statisticians in developing some guidelines for plot size and replications in progeny testing, published interim results on local plantings of the Southwide Pine Seed Source Study, developed a method of estimating crops in seed production areas and seed orchards, determined the quality of cones and seed produced in a seed production area, and tested a method of stimulating flowering in young seed orchard trees.

The Georgia Forestry Commission has thus far set out several hundred acres of seed orchards. The now-famous tree seed certification program in Georgia owes much of its strength to all these combined studies. Georgia's tree improvement and seed certification programs are setting the pace for the nation, and adoption of the same principles and methods used in Georgia is being considered by other member-states of the International Crop Improvement Association and by various sections of the Society of American Foresters.

Active support by industry has accelerated progress in tree improvement in the South. There are some 50 commercial seed production areas and seed orchards now totalling approximately 1,375 acres in the South. The Southern Region of the U. S. Forest Service plans to establish 3,130 acres of seed production areas within the next year in National Forests of 11 southern states, in addition to 1,210 acres of seed orchard as soon as possible.

At this point it may be well to explain that a *seed production area* is a thinned stand where the trees that look best (best form, fastest growing, disease free, for instance) have been left to provide crops of cones and seed. These better trees will wind-pollinate in uncontrolled fashion. But it is a step that can be made at once. It gives us seed, not from a wide variety, but from the better trees only. This procedure increases the chances of high production and should markedly raise the standards of southern pine plantations from now on. It is a partial, interim measure, however, intended to bridge the time until we achieve sufficient *seed orchards*. The seed orchard consists of proven strains whose seed are guaranteed to reproduce specified traits. And there are dozens of different traits—some mutually incompatible—desired by different industries. The proven stock for most of the seed orchards we should like to be setting out this year does not exist. So far, it is only in the case of gum orchards that the selection, progeny testing, crossing, further progeny testing, and grafting have been accomplished to produce southern pine seed orchards. The creation of seed orchards takes years. But it is an idea that southern foresters have seized with vigor.

This Georgia nursery is capable of growing a hundred million seedlings a year. Present tree improvement studies are primarily designed to serve the needs of such nurseries.

The original Lake City plantation of rooted cuttings from trees selected for high gum yield. Now 16 years old, the plantation also contains average trees for comparison. Note at right uniformity of small-branched row from small-branched mother tree, and at left large-branched from large-branched.

Lake City 15-year-old plantation of crosses between high-yielding parent trees. The man is looking at a tree whose gum-yields from micro-chipping were twice those of average trees; it also has 38 percent greater volume than average.

Slash pine in a progeny test for gum-yielding ability at Lake City. Established in 1951, this is the second planting of cross- and wind-pollinated seedlings. Gum-yielding ability was determined in 1961 by use of micro-chipping techniques and, as in the older plantation, genetic control of oleoresin production was shown.

A test plot of native and non-native species at Lake City, Florida, including Pinus massoniana, P. glabra, slash x loblolly pine hybrids, and P. sondereggeri. Of many non-native species tested here, none has grown so well as native southern pines. Similar tests of foreign tree species are being made in Georgia and the Carolinas.

Loblolly pine, left, of Arkansas race, and loblolly x pitch pine hybrid, right, at 14 years of age planted on the Lee Experimental Forest in Virginia. The loblolly pine is 35 feet tall, and the hybrid 33 feet. In this study, neither group has equaled growth of the North Carolina race of loblolly pine.

HIGHLIGHTS OF SOME SPECIFIC STUDIES

Variation and Inheritance

The gains that can be obtained by selective breeding for various traits depend upon the amount the traits vary within or between species and how strongly they are inherited. Thus, heritability percent times the selection differential, or the amount the trait varies from average, indicates the possible gain from selection. Such heritability estimates are of considerable value to the tree breeder.

Heritability estimates by several methods of computation were obtained for oleoresin or gum yield and many other traits in the same wind- and control-pollinated slash pine progeny planted at Lake City, Florida, in 1945. As shown in table 1, oleoresin yield under conditions of this study was strongly controlled by heredity.

During 1961, slash pine progeny test data based on 7- and 8-year-old trees planted in 1952 and 1953 at the Ida Cason Calloway Foundation were analyzed. Rather striking differences were found between progeny of various individual trees, and many of these traits could be related to the maternal parent. Heritability estimates shown in the following tabulation are high enough to be meaningful in tree breeding. All were determined by the method using components of variance and wind-pollinated progenies. Plantings were made in 1952 and 1953 with seed of the same trees.

Character	*Heritability percent*	
	1952 plantation	*1953 plantation*
Height	20	30
Diameter	6	34
Natural pruning	36	52
Crown width	—	19

Table 1.--Heritability estimates of different traits in 15-year-old slash pine at Lake City, Florida

Trait	Heritability percent 1/	Method used to estimate heritability
Oleoresin yield	45	Selection experiment
	56	Parent offspring regression of cross-pollinated progenies
	62	Female parent offspring regression of wind-pollinated progenies
	45-90	Components of variance with all wind-pollinated progenies
	2/ 90	Components of variance among clones
Wood specific gravity	21-42	Components of variance using wind-pollinated progenies
	56	Components of variance using cross-pollinated progenies
	2/ 73	Components of variance from clones of rooted cuttings
Summerwood percent	8-16	Components of variance using wind-pollinated progenies
	26	Components of variance using cross-pollinated progenies
	2/ 48	Components of variance using clones of rooted cuttings
Cubic-foot volume	18-35	Components of variance using wind-pollinated progenies
	31	Components of variance using cross-pollinated progenies
Height	8-16	Components of variance using wind-pollinated progenies
	13	Components of variance using cross-pollinated progenies
Diameter at breast height	29-58	Components of variance using wind-pollinated progenies
	33	Components of variance using cross-pollinated progenies
Crown width	24-48	Components of variance using wind-pollinated progenies
	12	Components of variance using cross-pollinated progenies
Bark thickness	33-67	Components of variance using wind-pollinated progenies
	57	Components of variance using cross-pollinated progenies
Oleoresin viscosity	58	Parent offspring regression using wind-pollinated progenies and clones
	100	Parent offspring regression using cross-pollinated progenies and clones
Oleoresin exudation pressure	65	" " " " " " " " "
Needle length	54	" " " " " " " " "
Needle divergence	75	" " " " " " " " "
Needles per bundle	33	" " " " " " " " "
Needle bundle volume	32	" " " " " " " " "
Fascicle sheath length	56	" " " " " " " " "
Bud scale length	81	" " " " " " " " "

1/ Narrow sense heritability unless indicated otherwise. Only additive genetic effects are included.
2/ Broad sense heritability includes nonadditive genetic effects (dominance and epistatic deviations) in addition to additive ones.

In the Callaway plantations some of the fast-growing progeny groups from disease-free mother trees had relatively little fusiform rust infection, while groups of run-of-the-mill seedlings had a high percent of trees infected. This finding is at variance with the generally accepted idea that fast-growing trees are more susceptible to rust.

Figures 1 to 5 show some of the results obtained when progeny of different mother trees were compared, when traits of progeny were compared with the parent, and when traits of progeny planted in 1952 are compared with those of the same progeny group planted in 1953. In general, it was found that traits of the mother tree were reflected in the progeny, that there were broad differences between progeny groups in good as well as undesirable traits, and that performance of progeny groups planted in 1953 was strongly correlated with that of trees planted in 1952.

An important study in wood quality for pulp yield was completed at Lake City, Florida, in cooperation with the Southern Institute of Forest Genetics. In the study, wood specific gravity and summerwood percent were obtained for several hundred trees from wind- and control-pollination, and 48 rooted cuttings. Highly significant differences were found in both summerwood percent and specific gravity between different progeny groups and between different clones. Specific gravity of the wood was only weakly correlated with summerwood percent. Specific gravity of the wood was positively correlated with tree height and negatively correlated with diameter. In other words, the trend was: the faster the diameter growth rate, the lower the specific gravity; and the faster the height growth, the greater the specific gravity. For volume, which is a function of both height and diameter, there was no significant relationship. The trees used in the study were 15 years old and fast-growing, in a plantation spaced 20x20 feet. A supplemental study with older and more closely spaced trees showed a negative correlation of wood specific gravity and tree volume. A striking feature of both sets of data was the wide variation in wood specific gravity between trees of the same progeny group (table 2) and between trees similar in size and rate of growth in the same stand.

From table 2 it can be seen that in progeny from controlled crosses the weight per cubic foot of wood may be as low as 27 pounds for some trees and as high as 37 pounds for others. Since wood specific gravity is a heritable trait, and yield of pulp and strength of poles and lumber increase as weight increases, differences of this magnitude are of great significance to industry. This is the first data proving range of specific gravity obtainable in crosses of selected trees.

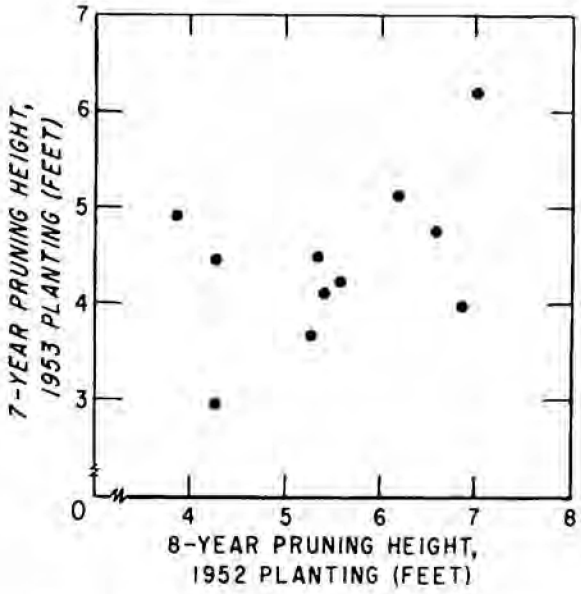


Figure 1.—The relationship of average pruning height for slash pine progeny groups in plantations established in two different years. Wide variation is indicated between progeny groups (4 feet to 7 feet) in height of natural pruning at 8 years, and the trait is consistent in different plantings.

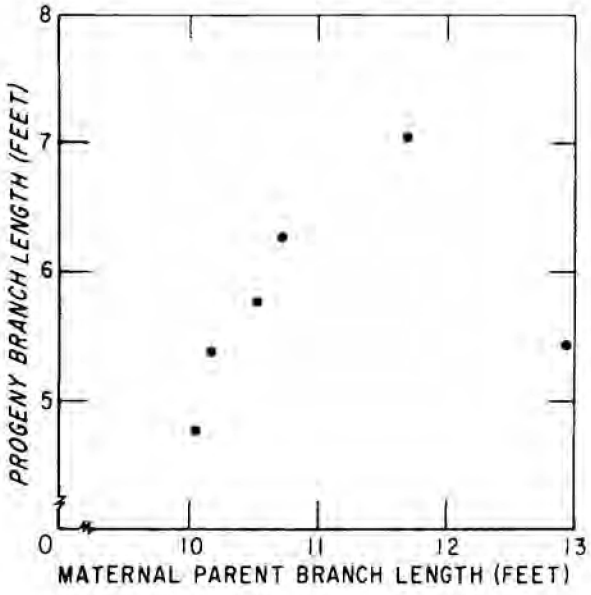


Figure 2.—Progeny branch length is the average length of the 3-year-old whorl (trees 7 years old). Maternal parent branches were measured in a zone between 65 percent and 80 percent of total height (trees 25 years old). One maternal parent that was open grown had a very wide crown, but the progeny had fairly narrow crowns. The data show that selection for short branches can be effective.

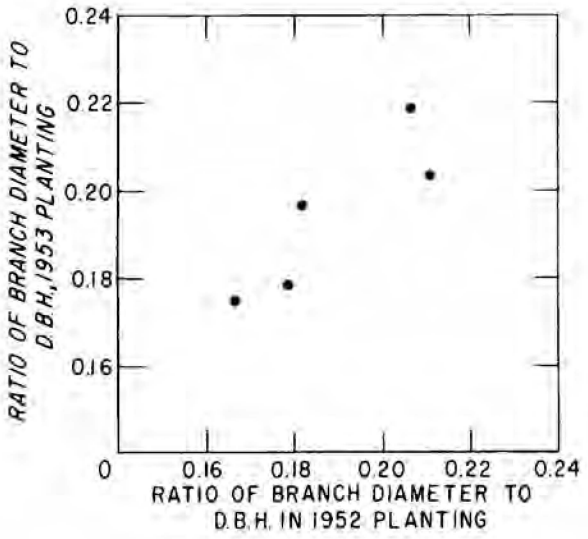


Figure 3.—The young trees were 7 and 8 years old, respectively. The data show that branch diameter of progeny from the same mother tree is consistent in plantings made in different years.

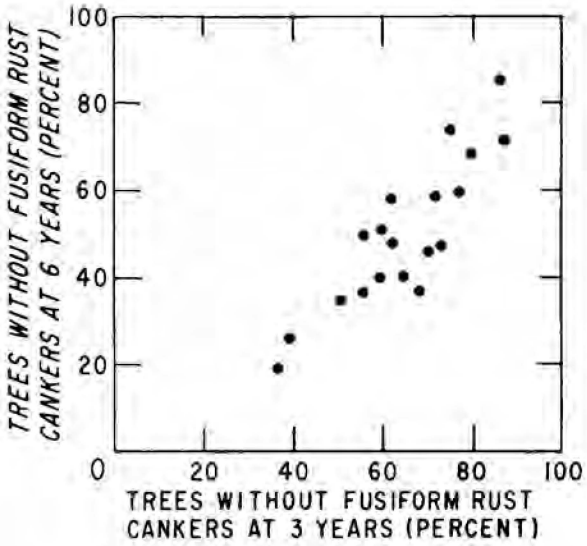
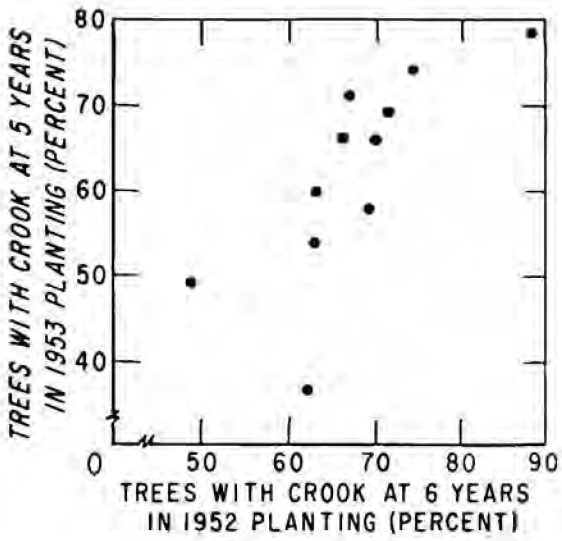


Figure 4.—Percentage of trees without rust cankers in different progeny groups at 6 years of age is here compared with percentage of rust-free trees at 3 years of age in same progeny groups. Indications are that the percent of rust-free trees varied from 40 to 90 percent at 3 years and 20 to 90 percent at 6 years between progeny of different maternal parents, and that if infection was low at 3 years of age it was low also at 6 years of age.



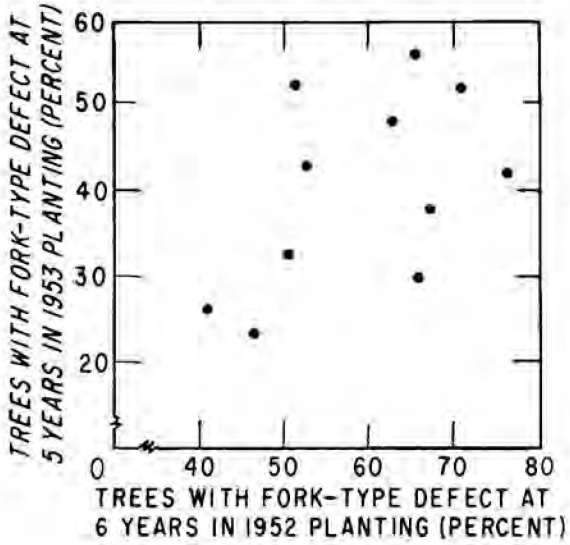


Figure 5.—The relationship of crook and fork defect in progeny planted in 1952 and 1953 of the same slash pine maternal parents. Progeny of individual maternal parents varied from 50 percent to 90 percent in crook and 40 percent to 75 in forking.

Table 2. --Number of trees by wood specific gravity classes in slash pine cross-pollinated progenies 15 years old

Cross	Wood specific gravity class									Total trees	Mean d. b. h.	Mean specific gravity
	0.41 to 0.42	0.43 to 0.44	0.45 to 0.46	0.47 to 0.48	0.49 to 0.50	0.51 to 0.52	0.53 to 0.54	0.55 to 0.56	0.57 to 0.58			
	Number									Number	Inches	
1x7	1	1	11	11	11	6	3	--	--	44	9.1	0.483
3x2	--	3	--	8	12	3	1	--	--	27	8.9	.487
10x7	--	2	--	8	17	5	3	--	--	35	8.8	.492
1x2	--	1	1	8	9	10	1	1	--	31	8.7	.497
4x1	--	1	3	3	11	5	5	2	--	30	8.8	.502
6x3	--	--	--	4	4	3	5	1	1	18	8.4	.512
3x6	--	1	--	2	3	5	3	2	1	17	9.4	.515
6x8	--	--	--	3	8	8	4	4	--	27	8.6	.515

Individuals from the crosses listed in table 2 ranged from 30 to 50 feet in height and from 4 to 14 cubic feet in volume. Having isolated these traits, as well as specific gravity, gum yield, and form, tree by tree, we were able to separate out the cream of the crop, i.e., from some 600 trees we have picked the few combining all these desirable traits. Germ plasm of these heavy, good-form, fast-growing, high-gum-yielding trees has been set out in four seed orchards.

In an attempt to find fast-growing individual trees, outstanding seedlings of slash pine were selected in Georgia and Florida, and loblolly pine in Georgia. In the Georgia study after 4 years the average plus seedlings of loblolly and slash were 16 and 19 percent taller, respectively, than control seedlings (fig. 6). In the Florida study they were 23 percent taller than the controls. In Georgia, survival of plus seedlings was about the same as for the controls; in Florida it was about one-half. Infection by southern fusiform rust was about the same in the plus seedling group as in controls, which was contrary to expectations.

A fairly large amount of information has been published on the variation and inheritance of tree form in slash pine, but much less has been available for loblolly pine. Recent results of a small study of the inheritance of branch length in loblolly pine in Virginia indicate this trait may be rather strongly inherited. In 7-year-old progeny from 7 wide-crowned and 7 slender-crowned trees, branches were longest in relation to tree height in the progeny of the wide-crowned trees. Height of progeny groups varied widely and the taller was 30 percent over the shorter.

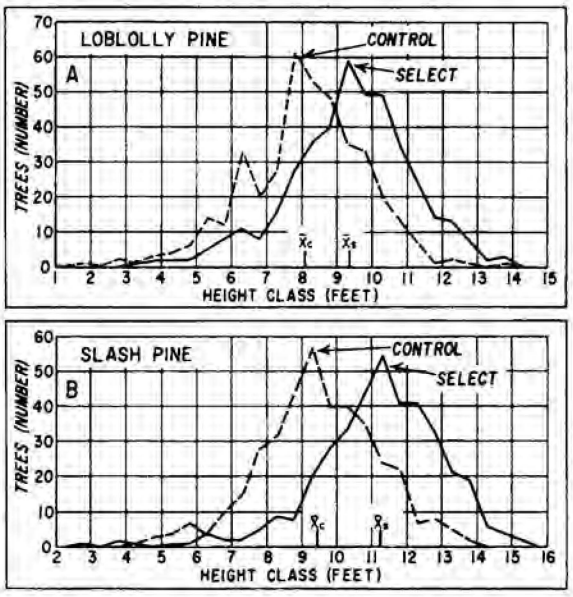


Figure 6.—Height frequency distribution of all loblolly pine seedlings (A) and all slash pine seedlings (B) after 4 years in the field. Selection of "super" seedlings in nursery beds has produced some very fast-growing trees.

Racial Selection and Racial Variation

The objective of racial selection studies is to determine the best races to plant in each of many different regions. Thus, racial variation study results showing only that races exist do not entirely meet the needs of the tree planter. He still wants to know what is the best race to plant in his particular area with its specific environmental complex.

The Southeastern Station has a fairly large program in racial selection studies, and cooperates with other Experiment Stations, the Tennessee Valley Authority, and individual researchers in additional studies. Including all the major southern pine species, a few hardwood species, and white pine, 217 different "races" have been planted in the Station's territory in 52 outplanting areas (figures 7 and 8).

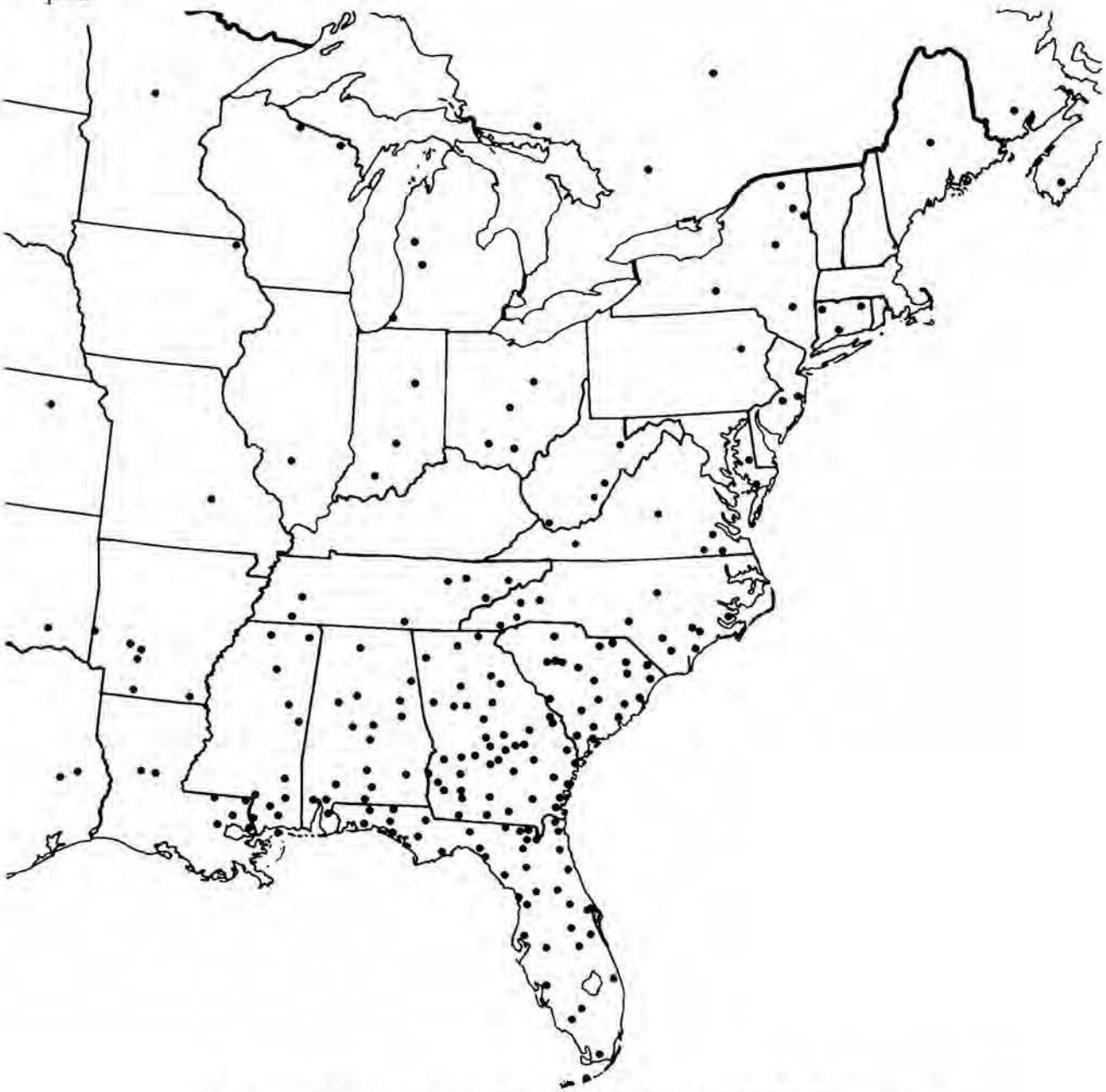


Figure 7.—Seed from 217 geographic locations is being used in racial selection studies of eight principal softwood and hardwood species by the U. S. Forest Service and cooperators.

Figure 8.—Location of 52 racial selection plantings by U. S. Forest Service and cooperators.

The pattern of racial variation and its importance in southern silviculture and tree breeding are indicated by the following samples from recent data. When planted in Piedmont Virginia north and west of its natural range in that state, loblolly pine from North Carolina had greater height and diameter after 15 years than loblolly pine from South Carolina, Mississippi, or Arkansas. Stem form was rated as poor because of a very high proportion of crooked trees. Trees from Arkansas had 15 percent forks, as compared to 5 percent or less in trees of other races—indicating inherent factors were present.

Five-year-old loblolly pine planted near the Atlantic coast of North Carolina (as part of the Southwide Pine Seed Source Study Series 1) to test effect of latitude and longitude of the seed source on survival and height growth showed highly significant relationships (fig. 9). Survival was positively correlated with latitude and negatively correlated with longitude and temperature zone. Average height of the two local (North Carolina) sources was about 8 percent taller than those from north of the planting area (Maryland), or south (Georgia), or south and west (Georgia, Alabama, South Carolina, Arkansas, Louisiana, and Texas), or west (Tennessee).

In middle Georgia, at 5 years of age, the same races that had been planted in North Carolina Series 1 showed a negative correlation in height growth with annual temperature zone, and a positive relationship with latitude. In this Georgia planting, the local Georgia and one Louisiana race

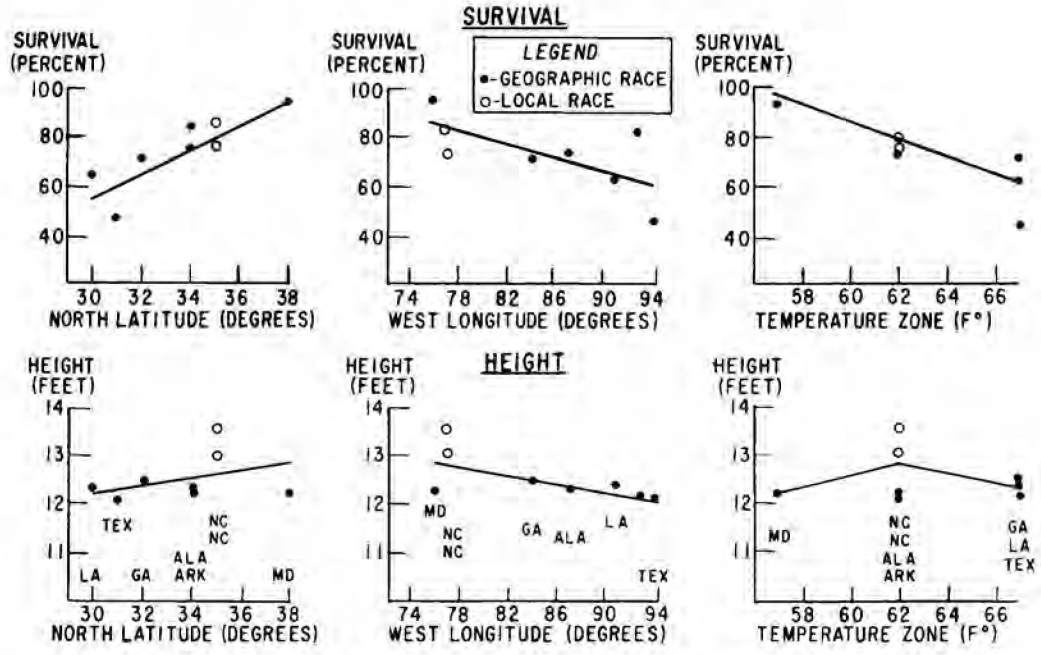


Figure 9.—Survival and height at 5 years of loblolly pine races when planted in eastern North Carolina, in relation to latitude, longitude, and temperature zone of the source of seed.

were 19 percent taller than the Maryland race. Survival was very good for all races. Rust infection was highest for the local race and lowest in the northernmost (Maryland) and westernmost (Texas, Arkansas, Louisiana).

In another plantation of loblolly pine in eastern North Carolina, Series 2 of the Southwide Pine Seed Source Study, made at the same time as Series 1, races of approximately the same latitude but different longitude were used. Survival of all races was about 80 percent or higher and did not vary significantly with longitude. However, total height of various races decreased as the distance west (longitude) from the planting site increased. The North Carolina race was about 25 percent taller than the two shortest (Clarke County, Arkansas, and Hardeman County, Tennessee).

Longleaf pine planted in southeastern Virginia as part of the Southwide Pine Seed Source Study varied in height and survival with source of the seed (table 3). The differences were greatest, however, between longleaf of southern Florida origin and others. Seedlings of Florida origin were badly damaged by cold.

In Georgia, longleaf pine 5 years old of eastern races were significantly taller than those from two locations in Louisiana but not taller than the Texas race. Survival was fairly high, and showed no significant relationship with longitude of the race. Average height and survival figures after five growing seasons appear below:

Source	*Average height* (Feet)
Baldwin County, Alabama	9.0
Treutlen County, Georgia	8.7
Polk, Tyler, and Hardin Counties, Texas	8.0
Washington Parish, Louisiana	7.7
Cleburne County, Alabama	6.8
Rapides Parish, Louisiana	6.2

Source	*Survival* (Percent)
Baldwin County, Alabama	88.8
Cleburne County, Alabama	84.7
Rapides Parish, Louisiana	84.2
Polk, Tyler, and Hardin Counties, Texas	82.6
Washington Parish, Louisiana	81.1
Treutlen County, Georgia	74.0

White pine seedlings of sixteen races in the United States and Canada were planted in the southern Appalachians in 1959. After 3 years it is apparent that growth is highly correlated with latitude of the race, the northern races growing much slower than the southern. Survival of seedlings has been good. After 3 years in the field in western North Carolina, seedlings of Canadian and northern United States races averaged about 1.3 feet, while local races were about 2.3 feet.

In a study of the effect of photoperiod on growth, photosynthesis, and respiration in loblolly pine, it was found that absolute and relative growth of long-day seedlings (15 hours) was greater than short-day seedlings (9.5 hours). Also, long-day treatment stimulated growth significantly more in seedlings of a Florida race than a Georgia race.

In summary we can say that in the South it is desirable to use southern pine seed or seedlings of a race as close as possible to the planting location. The correlation of height growth with longitude seems to be not so high as with latitude, but growth difference between extremes of the natural range can be of considerable economic importance. Local races may grow 10 to 25 percent faster than races from the extreme edge of the range, or, stated differently, growth of races from distant sources may be only 75 to 90 percent of that of local races. Additional information on growth, survival, wood quality, and susceptibility to disease, cold, and drought will be obtained as our studies in racial selection and variation con-

Table 3. --Six-year height and survival of longleaf pine of different geographic origin planted in Virginia

Seed source	North latitude	West longitude	Approximate average annual temperature	Survival 1/	Average height 1/
			Degrees F.	Percent	Feet
Nansemond County, Virginia	37°	77°	60	90.3	7.76
Rapides Parish, Louisiana	31° 12'	92° 42'	67	87.8	7.42
Harrison County, Mississippi	30° 36'	89° 04'	67	81.2	7.38
Treutlen County, Georgia	32°	83°	67	76.4	7.76
Hillsborough County, Florida	28°	82°	72-73	48.0	2.51

1/ Sources included within the brackets are not significantly different at the 1 percent level.

tinue. Even at an early age, the studies have contributed important information to guide seed procurement practices. This information plus that of the importance of the mother tree itself and performance of selectively bred strains must all three be combined if we are to get the best seed in the shortest time.

Techniques in Tree Improvement

In connection with the problem of deciding on optimum size for progeny test plots, it was found —from a series of measurements in a planted stand—that the coefficient of variation for tree height, tree diameter, height to live limbs, and bark thickness decreased rapidly as plot size increased to about 20 trees, and then it was fairly constant (fig. 10). This indicates that for these traits 25-tree test plots might be satisfactory.

In attempts to stimulate flowering of young grafted trees in seed orchards, tests were made in Georgia and Florida of the effect of changing branch angle on conelet production. Treatments in both tests failed to stimulate conelet production, and it was found that growth of branches decreased as the angle of branch increased downward to 120 degrees from the vertical.

Technical Assistance in Forest Tree Improvement

During the year, John Barber completed his Ph.D. thesis, analyzing slash pine progeny tests that had been established in 1952 and 1953 on lands of the Ida Cason Callaway Foundation. A summary will be published as a Station Paper.

In recent years needle, bud, or wood samples have been supplied to researchers for studies at the University of Florida, University of Georgia, North Carolina State College, and the Southern Institute of Forest Genetics. Results of the studies have been very helpful in developing some fundamental relationships for use in applied breeding. Material is still available for many additional studies.

In 1960 and 1961 the Station worked closely with National Forest staff of Region 8 in developing plans for and training of personnel in a Regionwide program to improve the genetic quality of tree seed.

A comprehensive plan for applied tree breeding and forest genetics research was prepared for the Georgia Forest Research Council to guide the work of various Federal and State agencies, including the University of Georgia, working in the State. The plan recommends studies to determine the best races of various species to plant in each region of Georgia, establishment of seed production areas and seed orchards to provide seed now of the best native stock, and selective breeding of hybrids within and between species to develop improved strains for growth rate, tree form, wood quality, and resistance to pests for planting in the future. A program of specialized studies in variation and inheritance is outlined to provide basic data for the applied breeding phase of the over-all program.

The Southeastern Forest Experiment Station continued working closely with the Committee on Southern Forest Tree Improvement in developing and guiding the tree improvement program in the South. Five papers were presented at the Sixth Conference on Southern Forest Tree Improvement at Gainesville, Florida.

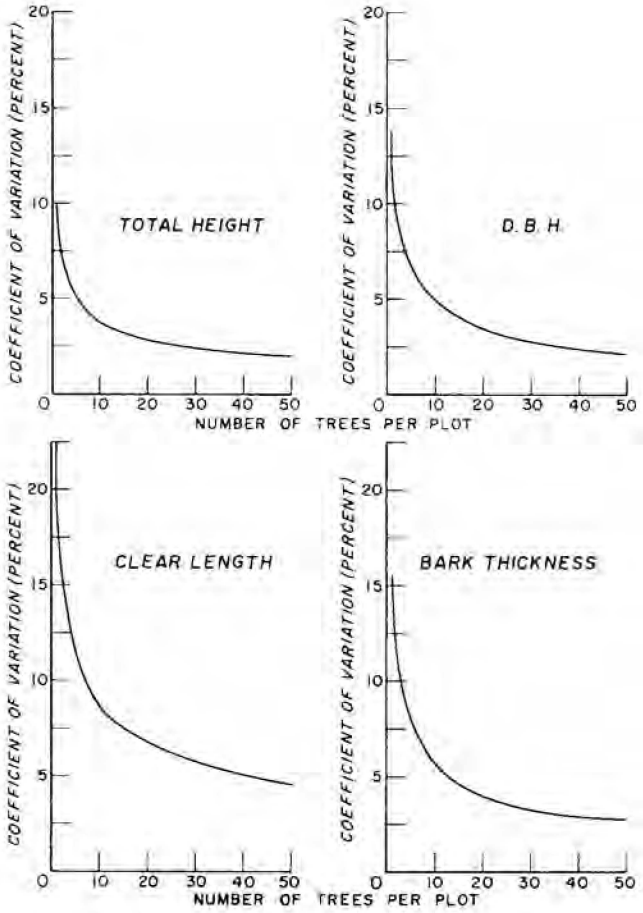


Figure 10.—Relationship of coefficient of variation for total height, diameter at breast height, clear length, and bark thickness to plot size in 10-year-old slash pine.

The Station is represented, also, on the Forest Biology Committee of the Technical Association of the Pulp and Paper Industry. Over a hundred abstracts were prepared for a bibliography of environmental and genetics factors affecting pulpwood quality. The bibliography will be published by TAPPI.

As an aid to research men and students working in forest genetics and forest tree improvement, the Southeastern Station has worked with the Southern Station in publishing an annotated bibliography of all papers in these fields by the two Stations.

Distribution of Genetically Improved Strains

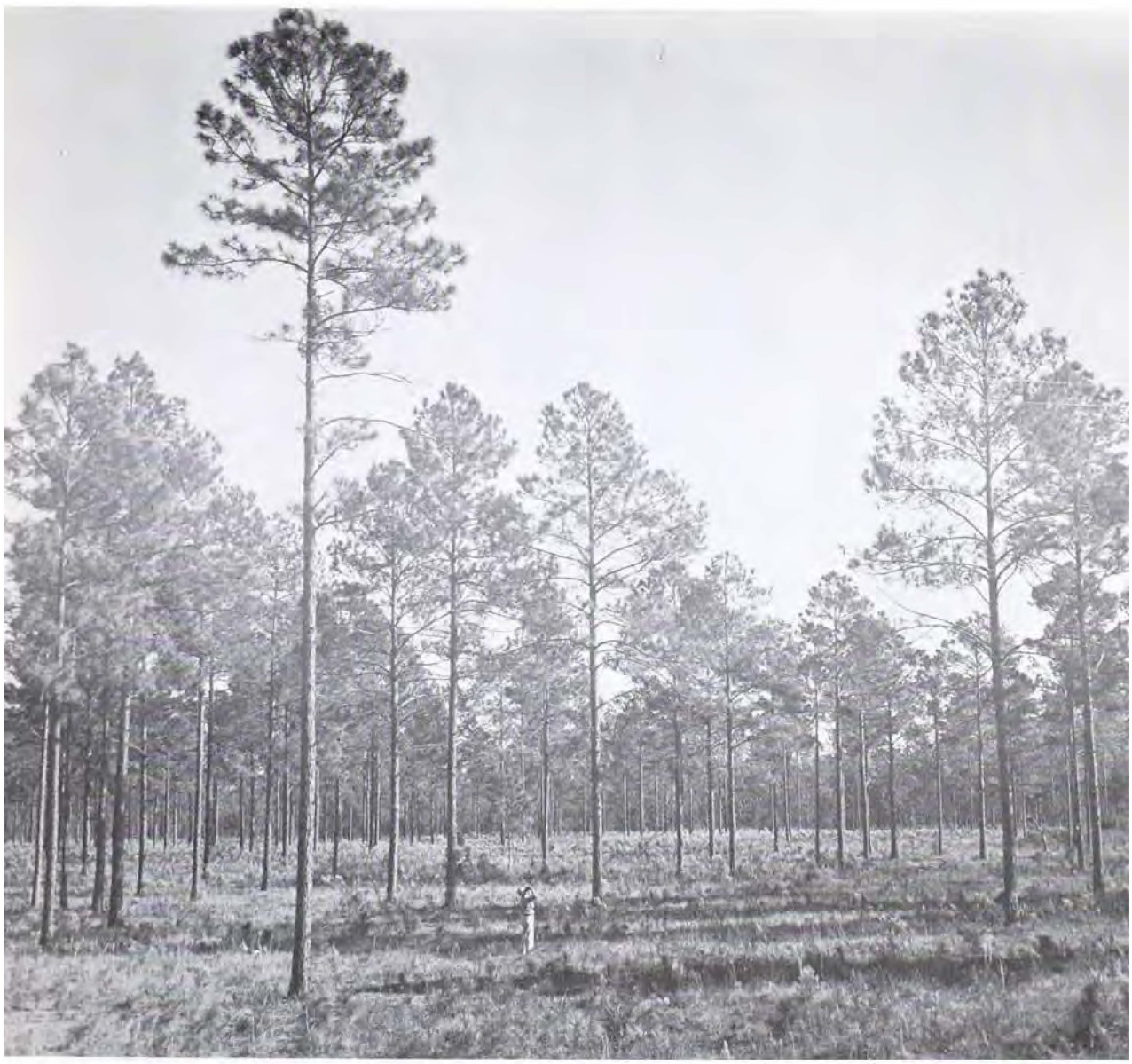
The Station has provided grafting material of high-gum-yielding strains to the Georgia Forestry Commission and the Louisiana Forestry Commission for establishing seed orchards. Distribution of clonal stock is a very satisfying development because it is the end product—improved strains—of all the work in techniques, racial selection, single tree selection, cross pollinating, progeny testing, and interpretation of progeny test data, that go to make up a tree improvement project.

Seed Certification

One of the results of applied tree breeding projects and research in the South has been development of a keen interest on the part of foresters responsible for large tree planting programs in the use of seed of the best racial and genetic stock available. To develop means whereby the tree planter can be confident of the quality of his seed, industrial foresters have taken a very active part in working with foresters in the Forest Service and State agencies to develop seed certification procedures—the first in the United States. Working through State Crop Improvement Associations, procedures and standards have been developed in Georgia and South Carolina. Under these procedures purchasers of certified seed are assured that seed is accurately labeled and uniform in quality and, if produced in seed production areas or seed orchards, that the areas and orchards were established according to specifications prepared by foresters on the committees of the Crop Improvement Association. Use of seed certification procedures is entirely on a voluntary basis both for the seed producer and seed purchaser—foresters can use them or not as they choose.

In 1961, the Continental Can Company, which has extensive lands throughout the South, collected over 300 pounds of certified slash and loblolly pine seed from a seed production area in Georgia. This was the first seed harvest under the Georgia Crop Improvement Association's program. That amount of seed will plant from 3,500 to 4,000 acres. The company, like a number of other organizations, plans to produce enough certified seed for its own use, with a surplus for sale.

The importance of seed quality is illustrated by the fact that sufficient seed is used each year to produce over 800 million seedlings of southern pines and in addition a substantial amount was used in direct seeding or exported. Over 325 million seedlings were planted on pulp and paper company lands alone in 1961. Research has shown that growth differences of 10 to 25 percent or more at 5 years of age occur between local races of southern pines and races from distant areas; also that desirable traits such as vigorous growth, straight trunks, small branches, good natural pruning, high oleoresin yields, and resistance to some important diseases are inherited quite strongly, even in open-pollinated seed. This is why southern forest industry is making every effort to use the best seed available each year.



Studies of seed production areas in Georgia and Florida have shown that reliable estimates of cone crop can be made by binocular count in early summer. Evidence to date shows seed and cones from seed production areas are larger than average and the cones are generally well filled, even where cone production from an individual tree is low.

Highly vigorous, well-formed, disease-free grafted slash pine clone 6 years old in a Georgia Forestry Commission seed orchard.

Good-form clone of loblolly field-grafted 1956 in a seed orchard.

End product of selection, progeny testing, and seed orchard establishment. Here is a row of 5-year-old trees from a cross between superior slash pine parents. These trees are uniformly good — in contrast to open-pollinated saplings in the same plantation, some of which are good and some bad. In the seed from seed orchards, produced by the natural crossing of superior parents, we expect to have the uniformity of desirable traits shown here.

These trees are the fifth link in a chain. First, twelve of the highest gum-yielding trees that could be found were selected from natural slash pine stands. Second, each of these exceptional trees was control-pollinated by hand with pollen of the others. Third, the seedlings from these crosses (and control seedlings from ordinary trees) were planted at Lake City in 1945. Fourth, estimates of gum-yielding potential were obtained for all trees by micro-chipping in 1956. Lastly, scions from the highest-yielding trees in various progeny groups were grafted in the seed orchard shown here. This orchard is expected to produce tree seed certified for high gum yield. A similar seed orchard has been established by the Georgia Forestry Commission. Scions for grafting are also being furnished to the Louisiana Forestry Commission.

PROGRESS IN OTHER FIELDS

Prescribed burning has been used with advantage for hazard reduction, for seedbed preparation, and for the control of broadleaved species in the coastal plain on sites where pine is to be the principal crop. However, the subject of prescribed burning often raises the question, "What effect does it have on the soil?" Station Paper 133 entitled "Some Effects of Prescribed Burning on Coastal Plain Forest Soil," by Metz, Lotti, and Klawitter, effectively answers many aspects of this question.

In the sandy coastal plain soils, annual and periodic burns had no significant influence on important physical properties (table 4). Organic matter in the mineral soil actually increased with all treatments except the periodic winter fire and, in general, the greatest amount of nutrients was found on the annual summer and annual winter burns (table 5).

Planting

A number of smaller studies reported during the past year have extended planting knowledge in the southeastern states, especially on adverse sites or with species for which planting prescriptions are still being worked out.

In northeast Florida, slash, loblolly, and sand pine were successfully underplanted in a 19-year-old loblolly pine plantation on an upland site. Eastern redcedar plantings were unsuccessful. In addition, growth of yellow-poplar and northern red oak was positively correlated with the percentage of nitrogen in the plant's leaves.

Planting large longleaf pine seedlings in the Carolina sandhills does not necessarily insure good survival and rapid height growth. After 5 years in the field, 1-0 seedlings produced desirable levels of survival and growth, while 1-1 and 2-0 stock did not. Other comparisons indicated that the over-all effect of foliage clipping was not appreciable; root pruning increased survival by 11 percent but reduced height growth by 0.5 foot.

Converting a 12x12-foot spacing of slash pine to 6x12 one year after the initial planting was judged a failure as far as the interplants are concerned. Fifteen years after the interplanting, the original trees had produced 17.26 cords per acre and the interplants only 1.65 cords. In addition, only 13 percent of the interplants are in a position to compete favorably with the original plantings.

In South Carolina it was found that 1-0 cypress seedlings with diameters 0.25 inch and larger at the upper end of the root collar make good planting stock. Seedlings of these dimensions had survival rates of over 90 percent, whereas smaller seedlings had survival rates of only 55 percent. Location also affected height growth; growth on well drained first bottoms was only two-thirds as much as growth on the wetter sites.

Table 4. --Some physical properties in the upper 4 inches of the soil related to fire treatments

Treatment	Bulk density	Retention pore space	Detention pore space	Percolation rate
	Grams per cubic centimeter	Percent by volume	Percent by volume	Inches per hour
0- TO 2-INCH DEPTH				
Annual winter	0.98	36.60	20.57	8.52
Annual summer	1.01	38.53	17.13	5.13
Periodic winter	1.10	35.89	17.91	4.83
Periodic summer	1.02	35.99	21.50	8.96
None (check)	1.04	36.08	19.58	8.10
2- TO 4-INCH DEPTH				
Annual winter	1.24	34.42	14.59	2.57
Annual summer	1.29	35.12	11.88	1.80
Periodic winter	1.35	32.09	12.70	1.84
Periodic summer	1.34	32.26	13.99	2.80
None (check)	1.29	33.96	13.22	1.70

Table 5. --Amount of nutrients and pH in surface 4 inches of soil as affected by prescribed burning treatment

Treatment	Nutrients					
	N	P[1/]	K	Ca	Mg	pH
	Parts per million					
0- TO 2-INCH DEPTH						
Annual winter fire	1664	24	56	282	86	4.4
Annual summer fire	2038	26	54	435	96	4.8
Periodic winter fire	1129	14	29	168	48	4.2
Periodic summer fire	1478	19	36	252	52	4.3
No fire (control)	1238	13	36	174	52	4.2
2- TO 4-INCH DEPTH						
Annual winter fire	862	13	30	86	42	4.6
Annual summer fire	834	8	24	94	39	4.7
Periodic winter fire	577	9	19	68	20	4.5
Periodic summer fire	712	9	21	96	24	4.6
No fire (control)	702	7	24	85	34	4.5

1/ The Truog method as used on agricultural soils yielded but 3 to 7 ppm of phosphorus (no significance between treatments).

Results of three tests of direct seeding of oaks, one in the Piedmont and two in the mountains of North Carolina, indicate that white, northern red, and black oaks can be successfully regenerated by direct seeding. Best results were obtained with acorns that were planted in mineral soil. Screen protection, though effective, proved to be unnecessary in the Piedmont study, where all the acorns were planted in the soil. In the mountain studies screens were ineffective; survival of acorns on the surface was very low regardless of screen protection, while results were good with acorns planted in the soil, whether screens were used or not. Acorns used for direct seeding should be treated for weevil control and planted 1 to 2 inches deep in mineral soil. Planting may be done either in the fall or in the spring.

Weight and volume tables were developed for planted loblolly pine in the Georgia Piedmont. The equations for tree weight and volume to a 3.6-inch top diameter inside bark were:

$$\text{Tree weight in pounds} = -72.280052 - 1.145907(D)^2 + 0.25336232(H) + 0.16949407(D)^2H$$

$$\text{Tree volume in cubic feet} = -3.2914302 + 0.069568154(D)^2 + 0.05175864(H) + 0.00125878(D)^2H$$

Where:

D = d.b.h. in inches

H = total height in feet

Soil-Site Studies in Piedmont Hardwood and Pine-Hardwood Upland Forests

A comprehensive study of physical soil-site factors affecting site index of five important timber species was conducted in upland Piedmont forests. The trees and soils were sampled in 153 mixed pine-hardwood and hardwood stands representing an advanced stage of ecological development. Yellow-poplar, white oak, scarlet oak, black oak, and shortleaf pine were measured in various overstory mixtures of two to seven dominant species per plot.

Of the 63 soil and site variables considered in initial trials, fifteen promising ones were evaluated in detailed multiple regression solutions for each species. All possible combinations of 1, 2, and 3 soil-site variables were analyzed jointly with total age of trees.

The resulting equations were not strong predicting equations. They indicated that models used for soil-site investigations in subclimax softwood types will not produce useful guides for these climax forests. This is true in the Piedmont because few hardwood stands develop by invasion of open land, but gradually infiltrate into pine forests on soil of above average quality. The use of hardwood-dominated forests in the Piedmont for soil-site study also precludes fire, grazing, erosion, and destructive cutting. Limitations on plot selection imposed by natural development impose a similar limitation on use of the soil-site equations. They cannot be extended to apply to recently abandoned fields and severely disturbed woodlands.

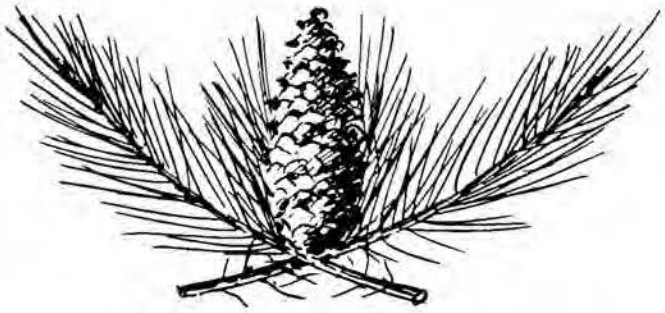
Nonetheless, the findings of this research provide some important facts about forest soil conditions that affect height growth of the species studied. Surface soil conditions and slope position proved to be important gauges of productivity for all five species. Thickness and organic matter content of the A_1 horizon, thickness of the total A horizon, and percent sand in the A_2 horizon were correlated with yellow-poplar height growth. Percent organic matter in the A_1 horizon was negatively related to site index of oak and pine.

Other findings include a positive effect of increase in slope percent on site index of black and scarlet oak, a positive effect of increasing latitude on site index of yellow-poplar, and higher site index for all species when yellow-poplar is present in the overstory. The complete results of this study were published in Forest Science, Volume 7, Number 4, December 1961.

Naval Stores

The production of turpentine and rosin is an important industry in the South, and researchers continued their efforts to work out methods for the coordination of naval stores operations with other timber management jobs, in order to learn more about factors affecting gum yield and about improvement of naval stores equipment.

An important paper by Karl Wenger discussed the newer methods of gum extraction and shows that the short-term working cycle fits well in timber management plans. Results of a study in Mississippi were published by Ralph Clements, showing that when working within a face height limitation of 54 inches, biweekly chipping with 1-inch streak height and 60 percent acid solution produced 6 percent more gum over a 3-year period than did weekly chipping. Other papers by Clements reported that for longleaf pine the proportion of scrape in the total season's yield is 20 to 24 percent; in slash pine 1 to 8 percent. It was suggested that scrape should be removed from tins as early as August to prevent wastage of gum. It was reported also that longleaf pine in Mississippi produced 30 percent of the total yearly yield during eight weeks in July and August, and the suggestion was made that trees be worked more intensively during this period if rainfall is adequate and streaks were missed earlier in the season. Another paper reported that galvanized iron cups for first-year work should be hung early enough for rain to collect in the cup before regular chipping with acid treatment was started, since this procedure reduces acid corrosion in the cup. In Georgia it was reported by Earle Jones that wide spacing of slash pine in plantations resulted in rapid growth, so that gum and sawtimber yields were high at an early age.



FOREST DISEASES

The White Pine Needle Blights

During the past year, work on the two white pine needle blights that we refer to as emergence tipburn and post-emergence tipburn has progressed rapidly. Emergence tipburn occurs throughout the range of white pine, but chronic post-emergence tipburn has been noted only in areas where industrial air pollution occurs.

A high degree of variation occurs between individual trees in their response to both diseases. These differences in tree-to-tree response are now known to be the result of differences in inherent susceptibility.

Previous work indicated, but did not prove, that both diseases were caused by abiotic atmosphere factors. In a recent series of experiments, when scion material from resistant trees was used in grafts the new growth remained healthy even in the presence of the atmospheric causal factor. Moreover, if susceptible scion material was used, its new growth developed typical symptoms if exposure to the causal factor was continued. These results suggested that uniformly susceptible test plants could be obtained by grafting scion material from a single susceptible tree. This was carried out with both diseases, and the resulting plants (ramets) have exhibited a high degree of uniformity in their susceptibility. In addition, ramets resistant to both diseases were made, using scion material from healthy trees.

Work on emergence tipburn, commonly called white pine blight, involved the use of susceptible clones. The causal agent of this disease was shown to be atmospheric in nature by exposing potted ramets to filtered and unfiltered air in plastic chambers in an eastern West Virginia area far from known air pollution during the period of shoot growth. Furnace filters impregnated with MnO_2, with and without activated carbon, were used. Ramets did not develop emergence tipburn when air was filtered through activated carbon (table 6).

A continuous recording of atmospheric oxidant concentration was made near the chambers during the time of the experiment with a Mast ozone recorder. Symptoms on unprotected ramets and on field-grown susceptible trees appeared 24 to 48 hours following an oxidant registration of 6.5 pphm, the highest level recorded during the exposure period.

Since the ozone recorder used in this work is not specific for ozone but also records other oxidants, field oxidant exposures were duplicated in the greenhouse by means of artificially produced ozone. Susceptible and resistant ramets were placed in a plastic bag; ozone was generated with three General Electric G4S11 mercury lamps. Air was circulated in the bag by means of a small electric blower. Typical emergence tipburn symptoms were produced on 9 of 10 susceptible ramets exposed for 4 hours at 6.5 pphm, the exposure recorded in the field on July 1. Check plants kept in the chamber but not exposed to ozone were unaffected. Resistant ramets exposed to 6.5 pphm for 4 hours were unaffected.

Post-emergence tipburn was shown to be caused by atmospheric factors in an experiment using susceptible, grafted ramets as biological indicators. To insure that soil conditions in the check plot were the same as those in the treatment plots, all ramets were potted in plastic buckets, using soil from a single location where the disease was unknown. In addition, the soil inside the plot areas was fumigated with methyl bromide, and the buckets containing ramets were sunk in the fumigated soil. All plots were mulched with straw which had also been fumigated with methyl bromide.

Two test plots were located in the vicinity of Rockwood, Tennessee, near the Kingston steam plant, the Oak Ridge atomic energy laboratories, and two ore smelters. A check plot, containing

Table 6.--Protection of susceptible grafted white pines from emergence tipburn when kept in filtered air chambers

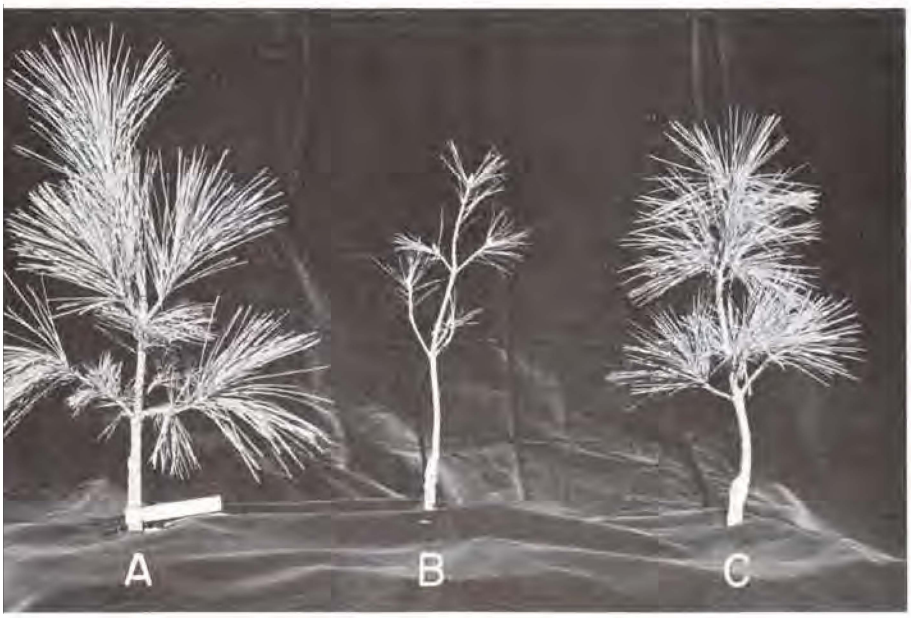
Treatment	Ramets used	Ramets showing symptoms of emergence tipburn	
	Number	Number	Percent
No chamber and no filter	12	12	100
Chamber but no filter	12	9	75
Chamber with MnO_2 filter	12	11	92
Chamber with MnO_2 plus activated carbon filter	12	2	17

ramets developed from the same parent material as those in the Kingston plots, was located near Asheville, North Carolina. No sources of air pollution of the types found around Kingston are in this area. The experiment was installed in April 1961, and by September 1961 all older needles on the susceptible ramets in the Kingston area had been prematurely cast. There were also strong symptoms of post-emergence tipburn on their current needles. None of the ramets in the check plot at Asheville had any symptoms of post-emergence tipburn by the fall of 1961 (table 7).

Indications from the results obtained this year on the white pine needle blights are that emergence tipburn is caused by an atmospheric oxidant, probably ozone, whereas what we term chronic post-emergence tipburn is caused by an undetermined atmospheric condition occurring in industrial areas.

Table 7. --Response of susceptible and resistant ramets to apparently polluted vs. unpolluted air

Plot locations	Clone No. 1 (susceptible)		Clone No. 2 (susceptible)		Clone No. 3 (resistant)	
	Ramets used	Ramets showing symptoms by fall 1961	Ramets used	Ramets showing symptoms by fall 1961	Ramets used	Ramets showing symptoms by fall 1961
	Number					
Clean air, near Asheville, N. C.	26	0	26	0	--	--
Questionable air, Plot 1, Kingston, Tenn., area	28	28	27	27	10	0
Questionable air, Plot 2, Kingston, Tenn., area	28	28	27	27	11	0



A, resistant graft kept in the Kingston, Tennessee, area from April until November 1961. B, susceptible graft kept in the Kingston area during the same period. C, susceptible graft, from the same clone as graft B, kept near Asheville, North Carolina, from April until November 1961.

Annosus Root Rot

Recent observations on annosus root rot in the Southeast show it capable of causing serious damage in some loblolly, slash, and white pine plantations. Heavily infected plantations have been found on soils ranging from deep sands along the coast to mountain clay loams. Serious damage can occur on good to excellent sites. Although the most severe damage has followed thinnings, several unthinned loblolly plantations have sustained heavy losses. While the heaviest losses have been in plantations, natural stands are occasionally attacked.

Occasional light damage has also occurred in shortleaf, pitch, and Virginia pine stands, even though in some cases eastern redcedar in the understory was heavily infected by *Fomes annosus*.

Preliminary indications from a large-scale annosus root rot survey in 1961 in the East and South are that damage tends to run higher in plantations, following thinning, on lighter soils, and in certain geographic areas, notably South Carolina. However, many thinned plantations of slash and loblolly had sustained little or no loss.

Littleleaf

During 1952-1953, thirty symptom-free shortleaf pines on two severely affected areas in Georgia and South Carolina were selected as possibly resistant to littleleaf, and as having other good characteristics. Scions from these selections were grafted on shortleaf pine seedlings and used to establish a breeding orchard at Athens, Georgia. Clonal lines of these grafted trees are remarkably uniform in growth rates, branching habits, and over-all appearance. Re-examination of the parent trees in 1961 disclosed that 5 of the original 10 trees selected at Hamilton, Georgia, had littleleaf symptoms or had died, and that 6 of the 20 selections made near Union, South Carolina, were diseased or dead. Resistance to littleleaf is probably relative, and the trees now remaining may be the individuals with the highest level of resistance to the disease.

The trees in the breeding area flowered abundantly in 1961. In cooperation with the Georgia School of Forestry, approximately 1,400 controlled pollinations were made, involving 78 combinations. As of November 1961, indications were that approximately 20 percent of these pollinations were successful. Some of these seed will be used for progeny tests on littleleaf sites.

Progeny derived from controlled pollinations made in 1953 between disease-resistant selections have now grown for four seasons on a severe littleleaf site at Union, South Carolina. They are making satisfactory growth and will afford a full test of progeny derived from possibly resistant parents.

Early in the investigations on the cause of littleleaf, scions from littleleaf trees were grafted onto healthy root stocks to determine whether a graft-transmissible virus was causing the disease. Littleleaf was not transmitted by grafting. Most of the grafted specimens have made good growth, and those from littleleaf scions, as well as those from healthy scions, are healthy and show no symptoms of the disease.

The 100-acre natural loblolly stand shown here was thinned 4 years ago, and today more than 25 percent of the trees are dead or dying of root rot.

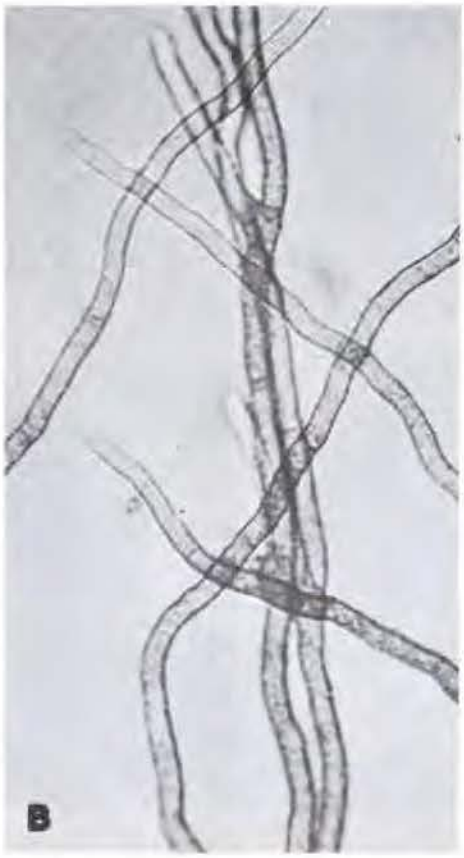
A, tree developed from cleft graft (made in 1948) of healthy shortleaf scion on healthy stock. B, tree developed from cleft graft of littleleaf diseased shortleaf scion on healthy stock.

Mycorrhizae of Southern Pines

Fungal symbionts have been successfully isolated in pure culture from mycorrhizae of shortleaf, loblolly, slash, and longleaf pines. These mycorrhizae are specialized root structures formed from the combination of a fungus and the pine roots, and are beneficial to the tree in that they permit increased absorption of nutrient materials.

In one test, success in isolation varied from 20 to 50 percent, according to type of medium used. Over 125 separate pure culture isolates, most bearing abundant clamp connections on hyphae, have been isolated from roots of 3- to 50-year-old trees growing in soil in the Piedmont and coastal plain regions of the Southeast. Over 30 different species of basidiomycetes appear to be represented. Mycorrhizae from wildling slash pine seedlings in a 1-acre area with a plantation in Georgia yielded 13 different basidiomycetous fungi and also *Cenoccocum graniforme,* a well known mycorrhiza-forming fungus.

Additional mycorrhizal associations have been confirmed by microscopic examinations of mycorrhizae formed in aseptic flask culture of shortleaf pine seedlings with pure cultures of the following fungi: *Amanita muscaria, Boletus communis, B. luteus,* and *Lactarius deliciosus.*



Isolation in pure culture of two different mycorrhizal fungi from a 1 cm. length of slash pine seedling rootlet. A, symbionts growing from separate mycorrhizae into agar medium. B, Cenoccocum graniforme, a well known mycorrhiza-forming fungus. C, unidentified basidiomycete, bearing clamp connections on hyphae.

Cone Rust

Hydraulic spraying of slash and longleaf pine with ferbam has continued to give excellent control of cone rust. A regular 5-day spray schedule during flowering season is recommended for surest control under varying climatic conditions.

Since cone rust infection may occur simultaneously with attacks by thrips (*Gnophothrips piniphilus* Cwfd.) on developing slash pine flowers, a combined insecticide-fungicide treatment was tested. One and one-half pints of a 2-pound-per-gallon emulsifiable concentrate of heptachlor were added to the standard ferbam suspension and applied at weekly intervals (heptachlor omitted during the receptive period) during the flowering season. Significant control of both thrips and cone rust followed. Such a combined treatment may be valuable in seed orchard pest control programs.

An attempt to control cone rust in seed production areas by aerial applications of a ferbam suspension was encouraging. Ferbam, at the rate of 4 pounds per 100 gallons of water, with an application rate of 16 gallons per acre, was applied at weekly intervals during the flowering season. Light aircraft equipped with a boom-type spray apparatus made the applications over a 12-acre seed production area, resulting in a highly significant reduction in the amount of cone rust in the sprayed area when compared to a similar unsprayed area.

Antibiotic Research

Several years have elapsed since we began testing Acti-dione for control of white pine blister rust on eastern white pine. Three tests involving approximately 700 trees have been put in during the last 3 years. To date, no evidence has been found to indicate that this antibiotic has given any measurable degree of control. Fruiting was depressed by Acti-dione where the material came in contact with the cankers; however, it is not known if there is any relationship between depression of fruiting and eradication of the pathogen at the canker margin. Where cankers occurred above the zone contacted by the spray, very little reduction of fruiting resulted, indicating little translocation in sufficient quantities to be effective against the parasite, as measured by the depression of fruiting. Another year of observations on these antibiotic test plots will permit better appraisal of the effectiveness of this material.

Phytoactin, Acti-dione, and several derivatives of Acti-dione have also been tested for control of fusiform rust of southern pines. These antibiotics were evaluated on nursery stock for their possible immunizing effects. Nursery treatments included seed soaks, seed pellets, soil drenches, top dips, and foliar sprays. Inoculations with the fusiform rust fungus following these treatments have given infection rates as high following any antibiotic treatment as following no treatment.

Double tent with sprinkler system used to inoculate pine seedlings with fusiform rust fungus.

Nematology

The littleleaf disease of shortleaf pine growing on Piedmont soils from central Virginia to central Alabama results from a nitrogen deficiency in the tree caused by the dying of new root tips and fine roots. This root injury is attributed to damage caused by *Phytophthora cinnamomi* in heavy and wet soils, aggravated by poor soil aeration and low soil fertility. A survey was conducted to determine if nematodes played a role in this root injury of diseased shortleaf pine. The two specific objectives of this study were: (1) to determine what plant parasitic nematode species were associated with shortleaf pine having symptoms of littleleaf, and (2) to determine if a correlation exists between any given nematode species and the presence or absence of littleleaf. Shortleaf pine stands were randomly sampled throughout the Piedmont from Virginia to Alabama. One diseased and one healthy stand were sampled in each selected county. Five species of plant parasitic nematodes were commonly found associated with littleleaf trees (table 8).

Table 8. --Nematodes per pint of soil in shortleaf pine stands in the Piedmont

Nematode	Nematodes per pint of soil	
	Healthy stands	Littleleaf stands
	- -Average number- -	
American dagger (Xiphinema americanum)	77	77
Sheath (Hemicycliophora vidua)	60	90
Spiral (Helicotylenchus dihystera and H. erythrinae)	105	251
Lance (Hoplolamius galeatus)	65	22

Although both sheath and spiral nematodes were found about as often in healthy as in diseased stands, the populations in diseased stands were much higher than those in healthy stands. The American dagger nematode occurred just as frequently in diseased as in healthy stands; the counts of lance nematodes were generally higher in healthy stands.

A second survey was carried out to determine whether there was a correlation between annosus root rot of slash pine and any species of nematodes. Information of this type could be helpful in evaluating the possibility of nematodes providing root injuries that could serve as infection courts for *Fomes annosus*. The American dagger nematode was the only species constantly found in relatively high numbers, but there was no apparent correlation between this species and annosus root rot incidence.

Nursery Diseases

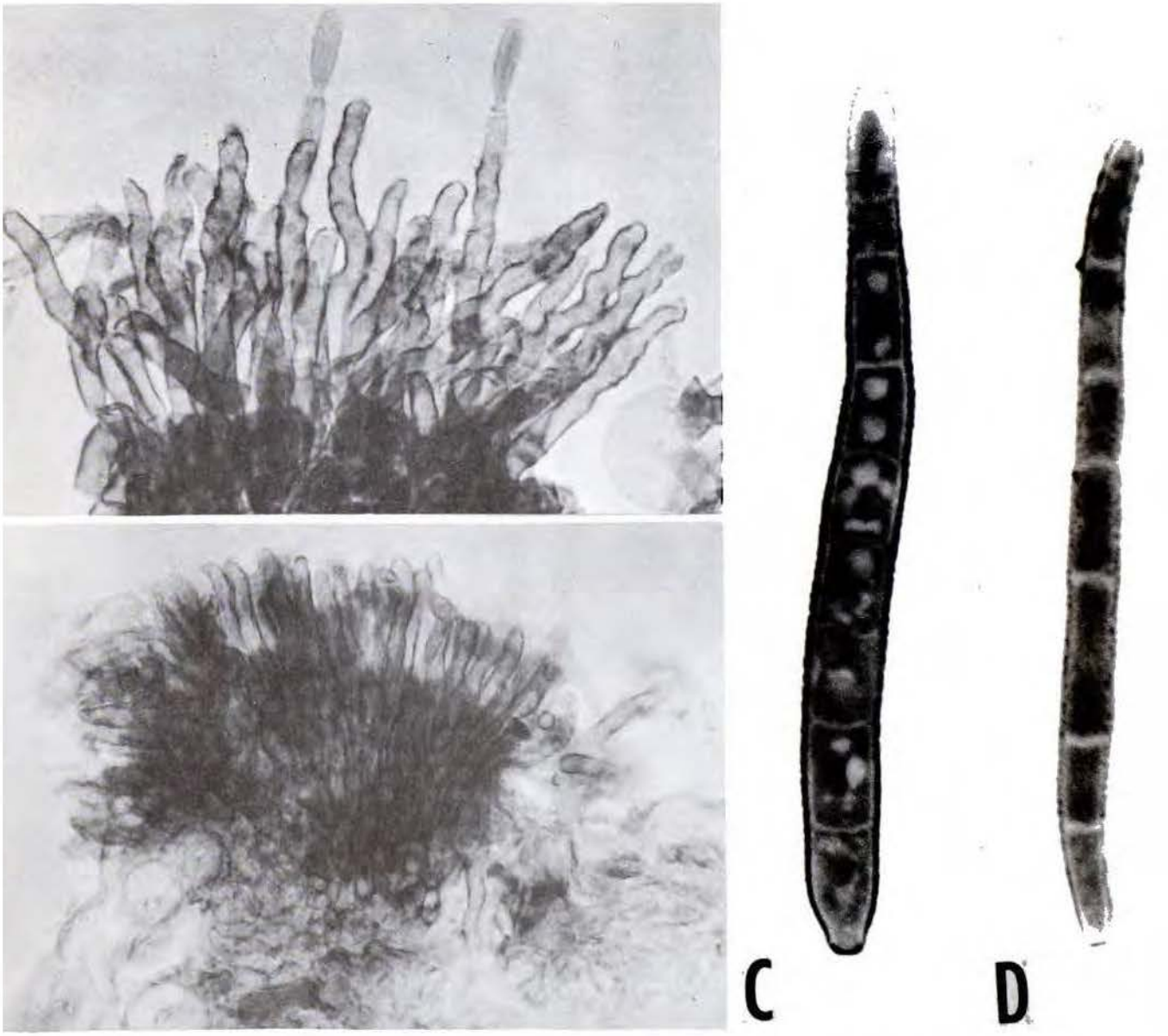
Continuing studies on the control of soil-borne diseases and weeds in forest nurseries have shown that Brozone (methyl bromide in mineral spirits), at the rate of 250 pounds actual methyl bromide per acre, and Trizone (61 percent methyl bromide, 31 percent chloropicrin, and 8 percent proparge bromide), at the rate of 260 pounds per acre, increased the number of plantable seedlings per acre by as much as 35 percent by eliminating most soil-borne disease organisms, and decreased the amount of hand weeding required by half or more. Trizone at the rates tested was superior to methyl bromide in respect to seedling growth.

Eptam was very effective in controlling weeds and had no effect on plant growth. The low cost of this chemical ($20 per gallon containing 6 pounds active ingredient) makes its use as a herbicide in forest nurseries very economical.

In another study, Vapam injected into the soil at the rate of 50 gallons per acre, and covered with a plastic sheet for 48 hours, gave favorable results comparable to methyl bromide with respect to seedling growth and was superior to methyl bromide with respect to weed control. The cost of this treatment is equal to or less than fumigation with methyl bromide.

A new disease of eastern redcedar caused by *Cercospora sequoiae* was found in several forest nurseries. The distinguishing symptom is a gradual browning of the needles, starting on the oldest needles on the lower branches and gradually spreading upward and outward. In advanced stages only the tips of the seedlings remain green. This disease is easily distinguished from Phomopsis blight, which mainly results in the death of the branch tips.

The disease symptoms caused by *Cercospora sequoiae* on both Arizona cypress and on redcedar seedlings are identical with those caused by a closely related fungus, *C. sequoiae* var. *juniperi* (previously identified as *Exosporium glomerulosum*), which causes a needle blight in eastern redcedar plantations. The two fungi are readily distinguished by the longer conidiophores and larger conidia of *C. sequoiae*.



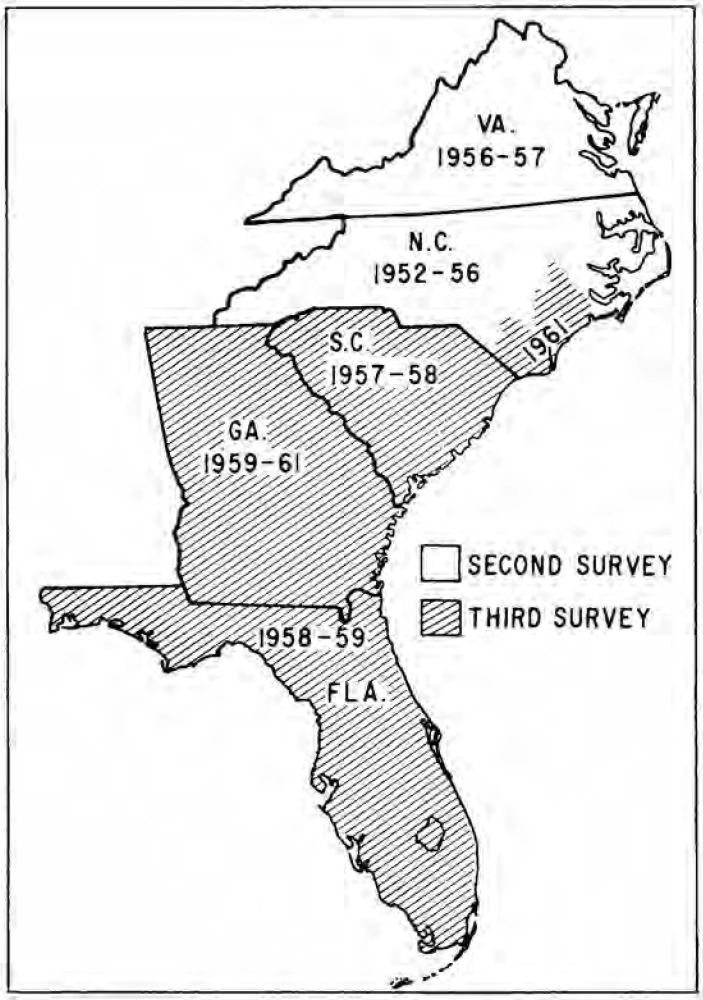
A, conidiophores and stroma of Cercospora sequoiae (x700). B, conidiophores and stroma of C. sequoiae var. juniperi (x500). C, conidium of C. sequoiae (x1900). D, conidium of C. sequoiae var. juniperi (x1900). Spores in C and D stained with cotton blue to show the septa.

FOREST ECONOMICS

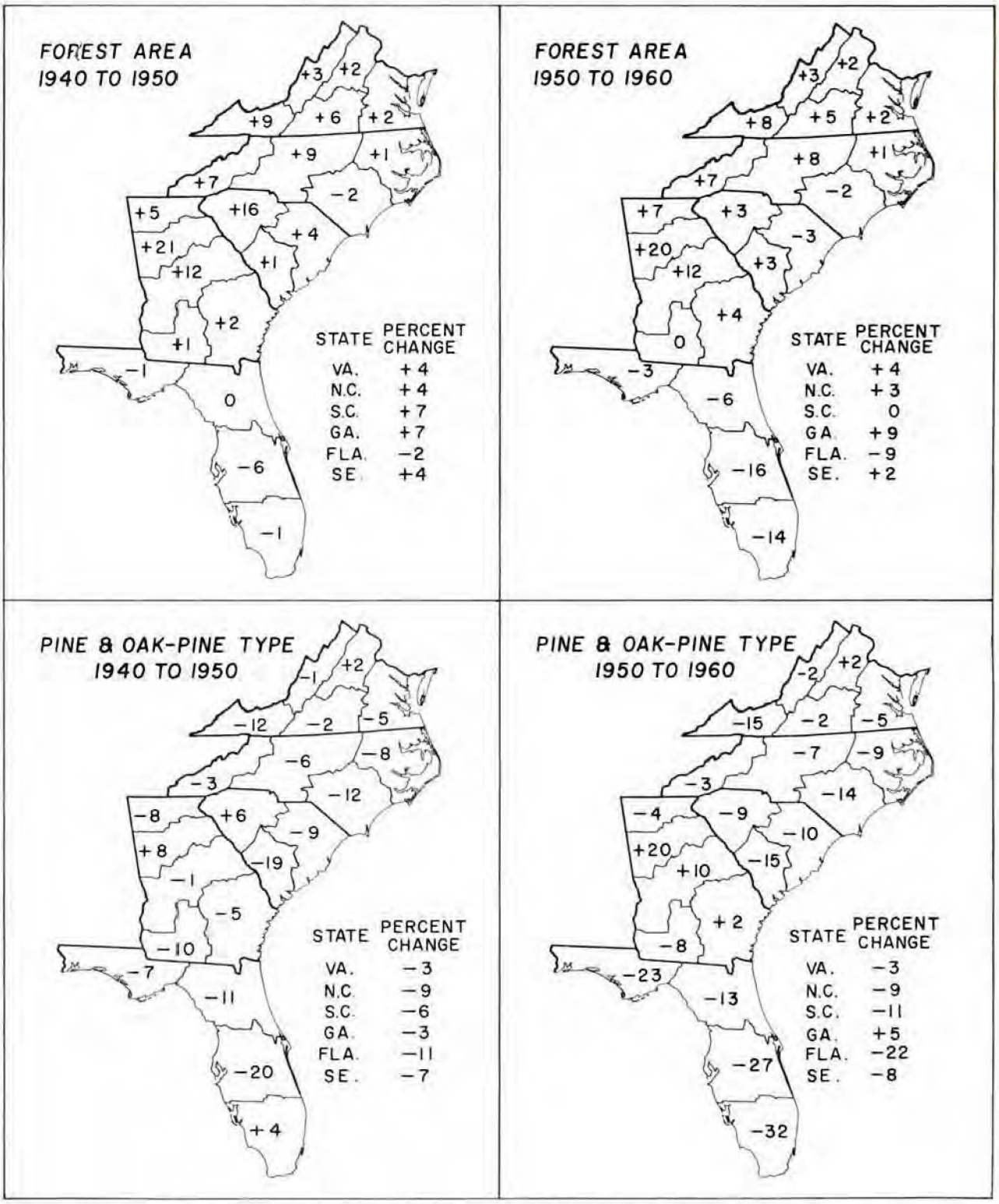
In May 1961, the final report of the third Florida survey was published. In August, field work for the third Georgia survey was completed, and the crews moved to the southern coastal plain of North Carolina, also for the third survey there. By year's end, preliminary statistics had been released for all five survey units in Georgia, and about half the field work in the first North Carolina unit was done.

Trends

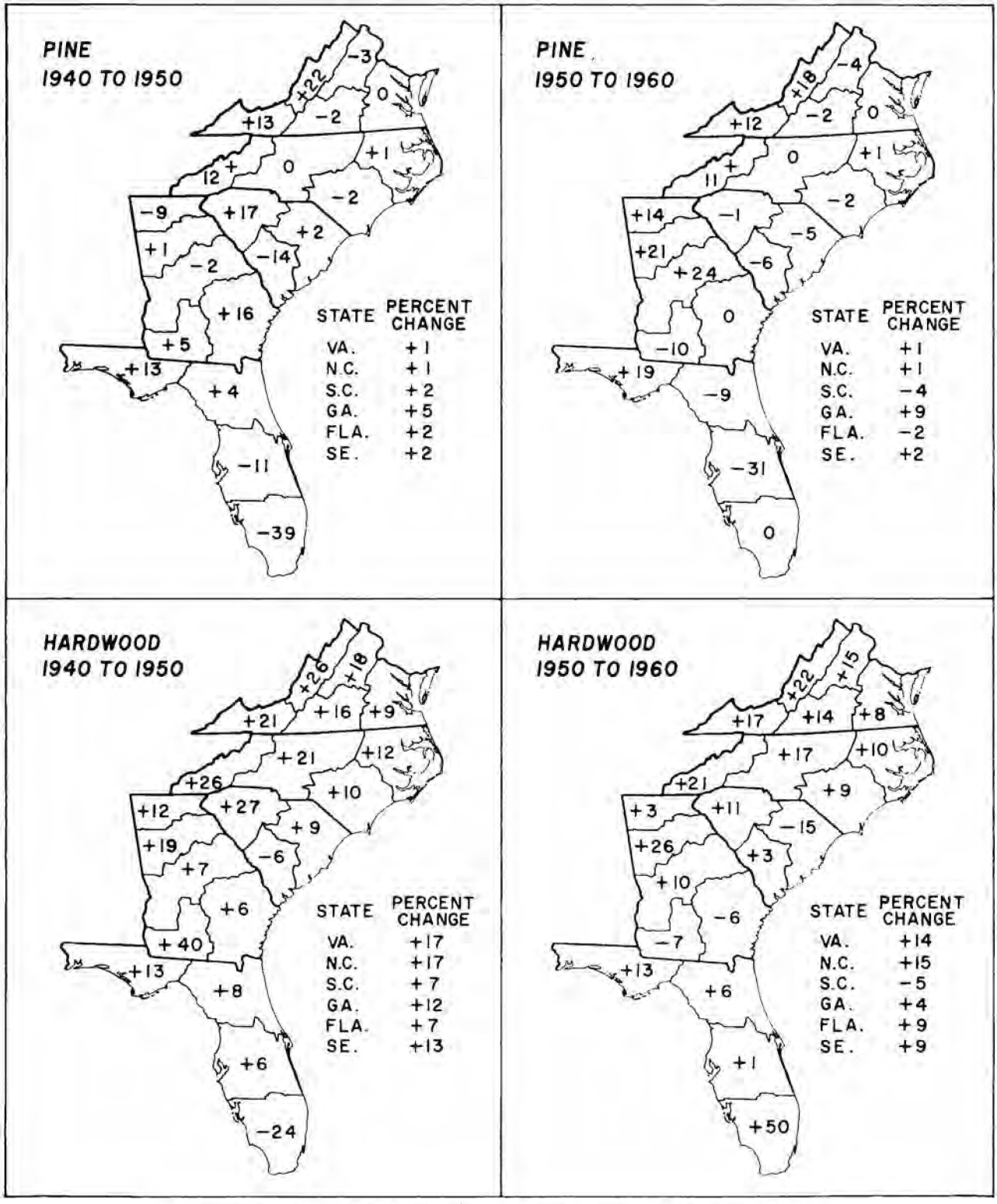
Three of the five southeastern states have now been surveyed three times. Each succeeding survey permits us to analyze timber resource trends with greater confidence and thoroughness. One consequence is that we have been able to transform the forest area and timber volume inventories to common 1940, 1950, and 1960 bases, permitting geographic comparisons of trends, regardless of dates of surveys.



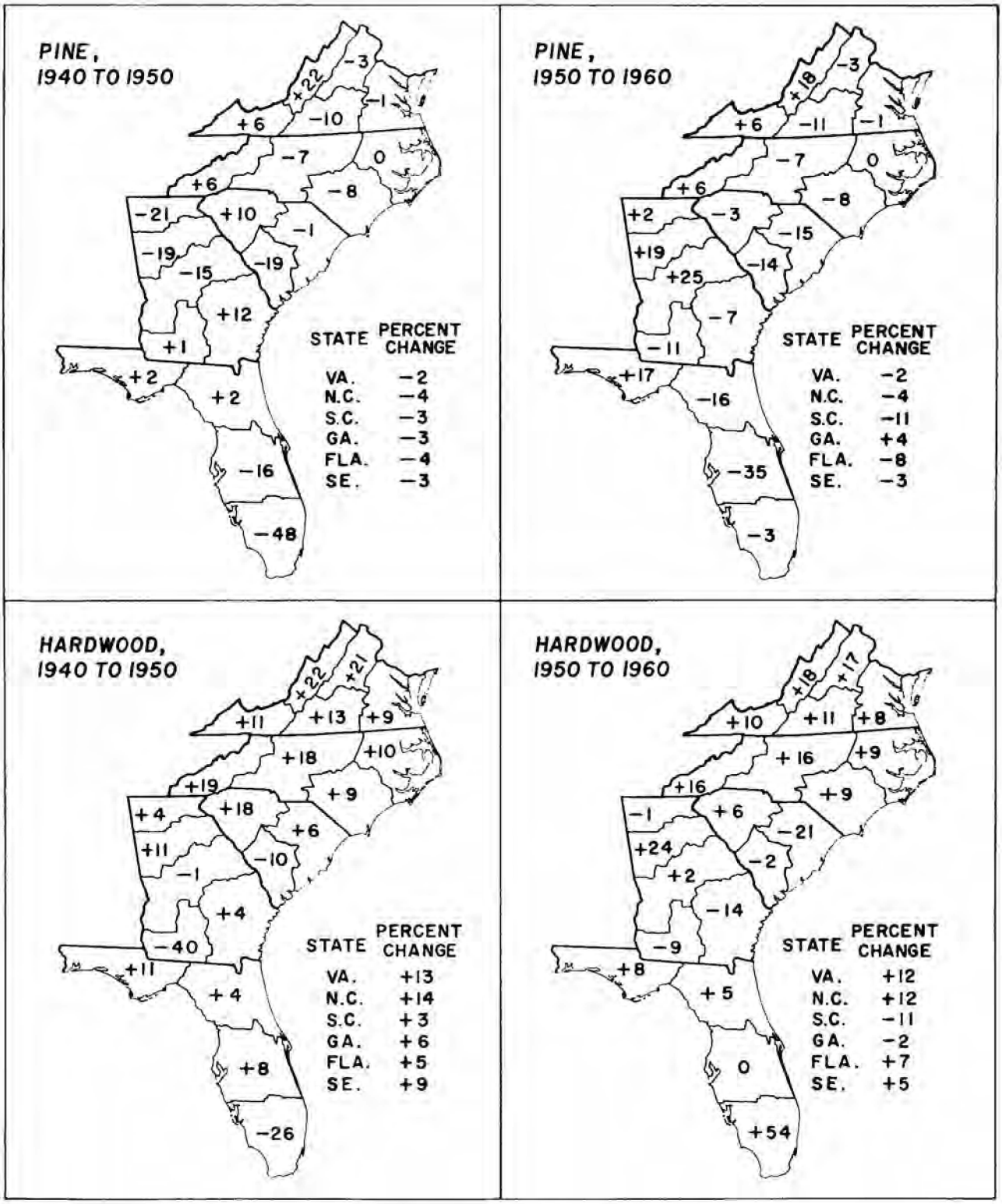
Status of Forest Survey field work in the Southeastern States.



Percent change in commercial forest area and area of pine and oak-pine types by Forest Survey Unit in the Southeast.



Percent change in all timber volume by Forest Survey Unit in the Southeast.



Percent change in sawtimber volume by Forest Survey Unit in the Southeast.

The first state to be surveyed for the third time was South Carolina, in 1958. This survey showed that the timber supply outlook in South Carolina had become less favorable during the preceding 10 years. Pine sawtimber, which had decreased only 3 percent between 1940 and 1950, decreased 11 percent in the fifties. Hardwood sawtimber, which had increased 3 percent during the forties, also decreased 11 percent between 1950 and 1960.

Completion of the third surveys for Florida and south Georgia disclosed a similar situation. With the exception of northwest Florida, unit-by-unit trends during the fifties were less favorable than those during the forties. Total pine volume, which had been increasing slightly prior to 1950, decreased; pine sawtimber, which had decreased, declined even more. Even the hardwood balance shifted from a surplus of growth to a deficit in some areas.

The results from the third survey of central Georgia, however, showed a sharp reversal in trend since 1950. Total pine volume, which had decreased slightly between 1940 and 1950, increased 24 percent during the next 10 years. A 15-percent reduction in pine sawtimber during the forties became a 25-percent increase in the fifties. Forest area continued to increase 12 percent per decade.

The third survey of the remaining two units in Georgia, the north central and northern units, showed the same continuing increase in forest area and upward trend in pine volume as in the central unit.

This improvement in the timber supply outlook in central and north Georgia more than offset the less favorable aspects in south Georgia. Thus, the third survey for Georgia, in contrast to South Carolina and Florida, presented a more favorable outlook in 1960 than 10 years ago. Forest area has increased more during the past 10 years than during the forties. Planting and natural reversion of cropland to forest has more than offset the replacement of pine by hardwoods. Area of pine and oak-pine type has increased since 1950, reversing the previous downward trend. Pine increased more during the fifties than during the forties, and pine sawtimber growth has more than replaced the cut and mortality. The decrease in large pine sawtimber has leveled off from 31 percent between 1940 and 1950 to only 3 percent since 1950.

Hardwoods have not fared quite so well as pine in Georgia during the past 10 years. Total hardwood volume, which increased 12 percent between 1940 and 1950, increased only 4 percent in the fifties. Hardwood sawtimber growth failed to replace the cut and mortality, in contrast to a surplus of growth during the forties.

For the Southeast as a whole, the timber supply outlook has changed very little in the past 10 years. Improvements in some areas have just about offset deterioration in others. Forest area is continuing to increase, but not so fast as formerly. Total pine growth continues to exceed the cut, but only by a slight margin. Pine sawtimber growth is still just short of maintaining the pine sawtimber volume. Hardwood growth, both total and sawtimber, continues to exceed the cut and mortality by a comfortable margin, although recent surveys indicate the margin is narrowing.

Innovations

The information now being collected on the North Carolina survey includes all items previously covered and several new ones. Most of the softwood species are sampled for specific gravity. Forest areas are classified according to silvicultural condition and treatment needs (area condition class). All timber resource information is to be compiled by occupation of owner and acreage owned as well as by the several classes of public and private ownerships recognized in the past. Land under lease to wood-using industries is another category recognized. These breakdowns will help to indicate how much of the timber is already committed and how much is still available for new plants. They will also facilitate analysis of forestry accomplishments and problems, which are known to vary greatly by type of ownership.

Another innovation will be a supplementary survey of plantations to obtain accurate acreages by species, age, site, and stocking. This information will enable us to see how timber supply trends will be influenced as the planted trees grow to merchantable size.

Activities

Forest Survey activities included a special study whose purpose is to develop equations sufficiently precise for all volume and growth calculations, yet easily handled on electronic data processing machines. We hope to publish equations for the principal southeastern tree species early in 1962.

Continued cooperation with the Southern Pulpwood Conservation Association and the Southern Forest Experiment Station produced the sixteenth annual report of pulpwood production in the South. The 1960 output of nearly 24 million cords set a new record (table 9), and Georgia led all the other states by a wide margin. A companion study resulted in a Research Note which brought up to date a price series for pulpwood at typical points of delivery.

The Division also participated in a nationwide survey of "Wood Used in Manufacturing, 1960," on which the Forest Service and Bureau of the Census are cooperating. This project, involving

Table 9. --Pulpwood production in the South, 1960, and change since 1959

State	Round pulpwood and residues	Change
	Thousand cords	Percent
Alabama	3,019.7	+3
Arkansas	1,555.9	+2
Florida	2,100.4	-1
Georgia	4,905.8	+4
Louisiana	1,856.9	+3
Mississippi	1,973.6	-2
North Carolina	2,273.6	+6
Oklahoma	53.1	-3
South Carolina	2,190.4	+13
Tennessee	361.8	+2
Texas	1,426.4	+1
Virginia	1,833.4	+6
All states	23,551.0	+4

the collection, editing, and compilation of reports from many thousand firms, is continuing into 1962.

Progress was also made on a farm forestry study at Charlottesville, Virginia. This study, started in 1959 with the cooperation of the Virginia Agricultural Experiment Station, seeks to determine the economic place of forestry among the enterprises on southern Piedmont farms. Over a hundred farms have been examined and their woodlands classified according to silvicultural conditions and treatment needs. Treatment costs and product prices have been estimated.

Of two new studies undertaken during the year, the first, in North Carolina, will attempt to find out why some landowners practice forestry, while others with apparently equal opportunity do not. A hundred owners who do practice forestry have been interviewed to see if they share common factors of background, education, financial position, business or social environment, personal taste, and the like.

The second new study, in south Georgia, is obtaining information on timberland value trends since World War II and the possible relationship of individual tract prices to various stand-quality and locational factors.

How to Estimate the Price of Sawtimber

The chief question in the mind of a woodland owner offering his standing trees for sale is, "What price should I accept?" For most, this is difficult to decide. The average seller has not sold before, or at least not for a long time. He finds that timber, unlike many other commodities, has no organized market where he can easily learn the "going price." Furthermore, the variety of prices paid in different sales confuse him. Although vaguely aware that price depends on stand characteristics, he cannot understand their effect. A timber seller in this situation needs a simple appraisal method.

Such a method has been developed for southern pine sawtimber in South Carolina. It is based on two factors—average volume per tree, and road distance from the tract to the nearest sawmill or planing mill. Of 23 factors evaluated in an analysis of 93 sales that were made over a 10-year period, these two were the most important in explaining local price differences. By using this method, an owner can tell about what he should expect to get if he sells his timber as foresters advise—that is, he has his stand marked and cruised and tries to get three or more bids. Complete details of the procedure are given in Station Paper 122 by Walter Anderson.

FOREST UTILIZATION

Southern Pine Log Grades

Fourteen years of research by the Southeastern and Southern Forest Experiment Stations have resulted in approved Forest Service Standard Log Grades for southern yellow pine. These grades, formerly used on an interim basis, have been tested on the four major species of southern pine at local mills in South Carolina, Georgia, Florida, Mississippi, and Arkansas. A sample of logs from each location was also transported to one central mill to eliminate the variation interjected by different sawyers and different lumber graders.

The grades shown in table 10 are subject to reduction under certain conditions: Reduce grades Select, 1, or 2 one grade if sweep equals or exceeds D/3. Reduce grades Select, 1, or 2 one grade if conk, massed hyphae, or other evidence of advanced heart rot is found. Reduce grade 2 logs to grade 3 if bad knots (unsound or larger than D/6) cannot be contained in ¼ of one sawing face.

A full report is being prepared that will describe the application of log grades in detail. It will also predict lumber grade yields from each log grade with variations accounted for by old growth, second growth, species, and location. A companion publication will illustrate and describe southern pine defect characteristics as an aid to proper log grading.

Work is continuing on the development of southern pine tree grades to permit accurate appraisal of the value of standing trees. In the meantime, trees can be graded with considerable accuracy by grading the individual logs in standing trees.

Table 10. --Approved Standard Log Grades for southern yellow pine

Grade	Minimum scaling diameter	Maximum knot count (K) 1/
	Inches	Number
Select	17	2/ D/5
1	10	D/2
2	5	No limit
3	5	No limit

1/ K equals number of overgrown knots, plus the sum of diameters of sound exposed knots, plus twice the sum of diameters of unsound knots. Diameters are measured to the nearest whole inch at point of trimming.

2/ D equals the diameter of the small end of the log to the nearest whole inch.

Georgia Marketing and Industrial Directory

The Georgia Forestry Commission and the Southeastern Forest Experiment Station have cooperated in the preparation of Directories of Wood Using Industries in Georgia. Georgia county rangers visited all wood-using industries in the State, collecting data which were then transferred to IBM cards by the Macon utilization staff. Machine tabulations then made it possible to develop information by species, production, product, and location. Location can be determined by counties or by radius from a possible plant site.

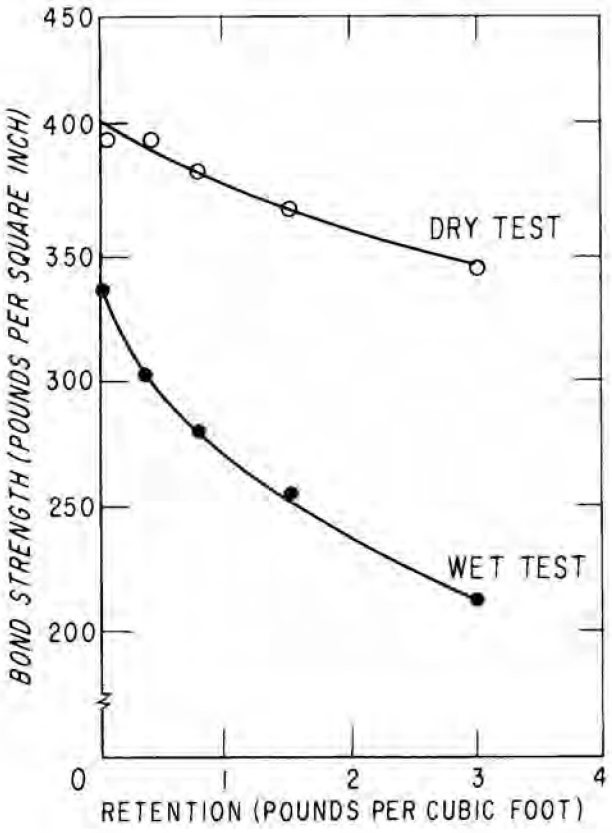
This wood marketing information will be kept current through continuous inventory of the wood industries in each county. County rangers will report changes so that IBM cards can be kept up to date. This reporting device has proved valuable to potential new wood industries and to established concerns as well. Adjoining states have indicated a desire to publish similar wood industry directories using the same technique.

Wood Preservation

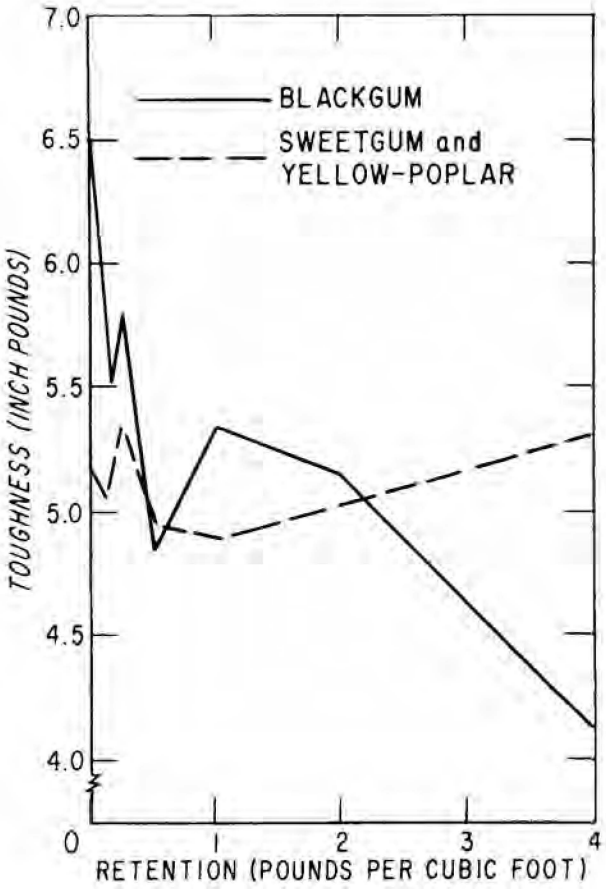
A study was completed on the diffusion of certain preservative chemicals into sweetgum sapwood veneer. Primarily, the study was concerned with the effect of heavy metal salts on gluing properties and toughness of the wood.

Plywood panels made from treated veneers showed important reduction in bond quality. The magnitude of the reduction varied with the particular combination of adhesive, salt formulation, and retention level, as well as the condition of the specimen.

Toughness of the treated wood was significantly lower than the untreated specimens. Heavy treatments with formulations having strongly acid reactions reduced toughness as much as 37 percent.



Relationship of bond strength to salt retention for sweetgum plywood.



Relationship between the toughness of veneer and preservative retention.

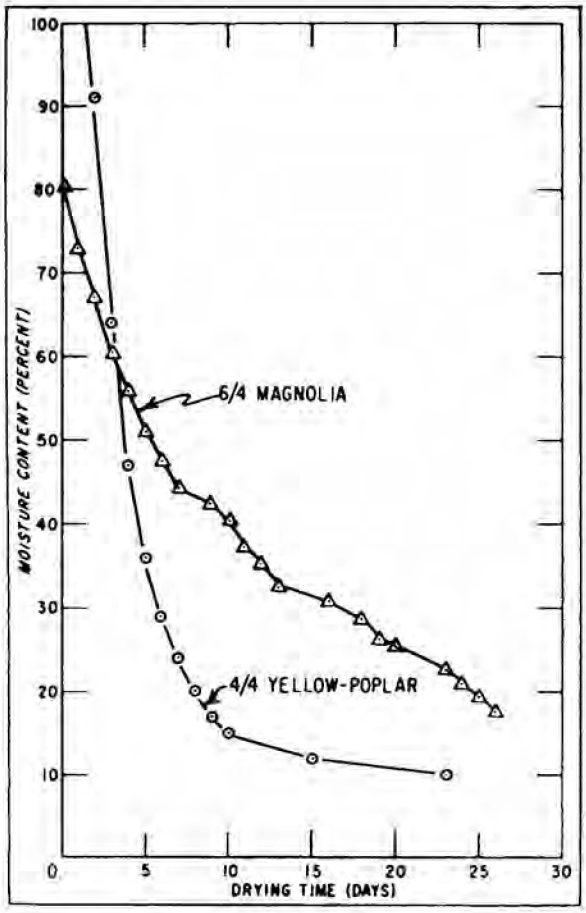
Forced Air Drying

Considerable research has been conducted on the forced air drying of southern pine and reported in previous annual reports and in technical literature. A summary of this research was presented in Station Paper 121 during the past year. Work has been going forward on similar research in hardwoods. One study was completed that compared research results with commercial results of forced air drying of magnolia at the Dixon-Powdermaker Furniture Company, Jacksonville, Florida.

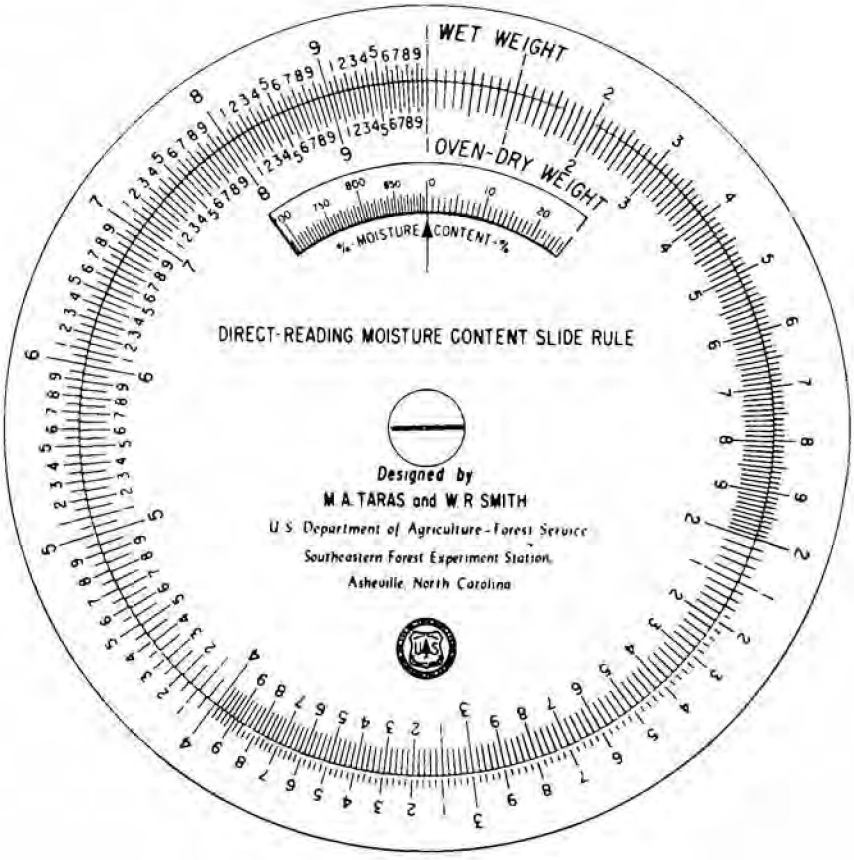
The commercial forced air dryer was a low-cost pole-type structure. Magnolia of varying thicknesses up to 2½ inches was placed in the dryer green. Since drying speed was not a requirement at this plant, a rather high maximum equilibrium moisture content of 14 percent was used and the dryer was operated only during daylight hours.

A comparison of the drying rate of 4/4 yellow-poplar dried in the research forced air dryer at Athens, Georgia, with a commercial run of 6/4 magnolia dried in the commercial dryer under adverse winter conditions at Jacksonville, Florida, showed that the basic principles of forced air drying applied in these tests. These principles include control of air velocity (about 500 to 600 feet per minute across the lumber), maintaining a minimum temperature of about 70° F., maintaining a controlled maximum EMC by regulating dry bulb temperatures, and restricting the length of air flow across the lumber to a distance of about 20 feet with periodic reversal of circulation.

Lumber degrade, especially chemical stain that had been plaguing the furniture company, was practically eliminated by forced air drying. The benefits, including a much reduced demand on the dry kiln, more than justify cost.



Comparison of drying rates of 4/4 yellow-poplar at Athens, Georgia, and 6/4 magnolia at Jacksonville, Florida.



A direct-reading moisture content slide rule developed for use by kiln operators and others engaged in work requiring numerous moisture content calculations. The slide rule simplifies calculation, reduces time of calculation, and helps improve accuracy by reducing the number of mathematical steps which are frequently the cause of errors in computations. The back of the slide rule is an equilibrium moisture content slide rule.

Particle Board Research

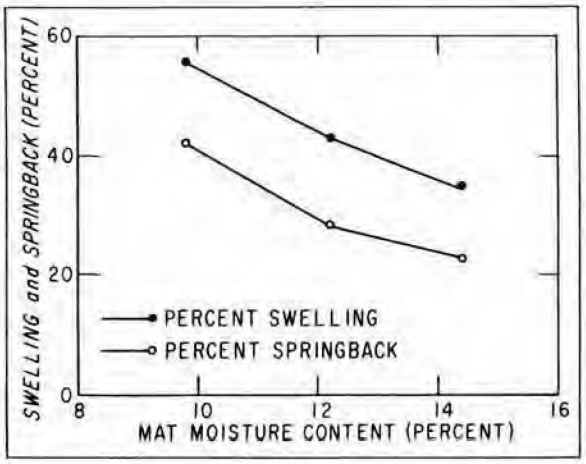
One of the less favorable characteristics of particle board, as compared to solid wood, is its tendency to swell in reverse to the direction of compression. Particle board exhibits swelling greater than solid wood of equal density, and also possesses a permanent retention of swelling called springback. The undesirability of this effect is obvious when one considers the use of such material where an appreciable moisture change might take place.

In cooperation with the School of Forestry, N. C. State College, a study was completed on the influence of manufacturing variables such as precompression, moisture content of wood particles, and hot press closing pressure on the mechanical and dimensional properties of a flatpressed flake-type particle board, with special emphasis on the dimensional properties.

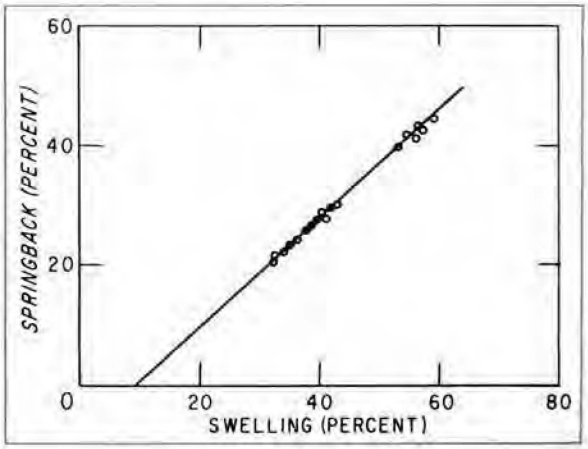
The results of this study showed that percent swelling and percent springback were strongly correlated.

The dimensional stability of the particle board manufactured in this study was improved considerably as the moisture content of the wood particles increased (swelling decreased one-third between 9 percent and 15 percent moisture content). This was most probably due to reduced compression set through greater plasticity during compression. In addition to these results, a substantial gradient in dimensional stability occurred across the thickness of the boards, with the center being more stable than the surface. This is also probably due to the reduction in compressive set through the plasticizing effect of a higher moisture content in the center during compression.

Maximum breaking strength and stiffness were increased 18 percent and 13 percent, respectively, with increasing moisture content from 9 percent to 15 percent. Tension perpendicular to the surface of the board was not influenced by the main effects studied, but a significant gradient appeared from the surface toward the center of the panel.



Effect of mat moisture content on percent swelling and percent springback.



Dependence of percent springback on percent swelling. Least squares regression equation as follows:

% springback = 8.61 + (0.909)(% swelling)

FOREST INSECTS

Pine Tip Moths

Research on tip moths is complicated by the presence of at least three species of *Rhyacionia* in southern forests. The problem of varying biologies and host preference is being studied by isolating the species in individual insectaries. Gravid moths were collected, placed in individual vials, and after oviposition on the sides of the vial, the moths were sent to specialists for identification. After receiving an identification of the moths, the first-instar larvae were placed on insect-free trees in the insectary. This year *R. frustrana* was successfully isolated. Five insectaries were constructed for these studies, each equipped with watering facilities.

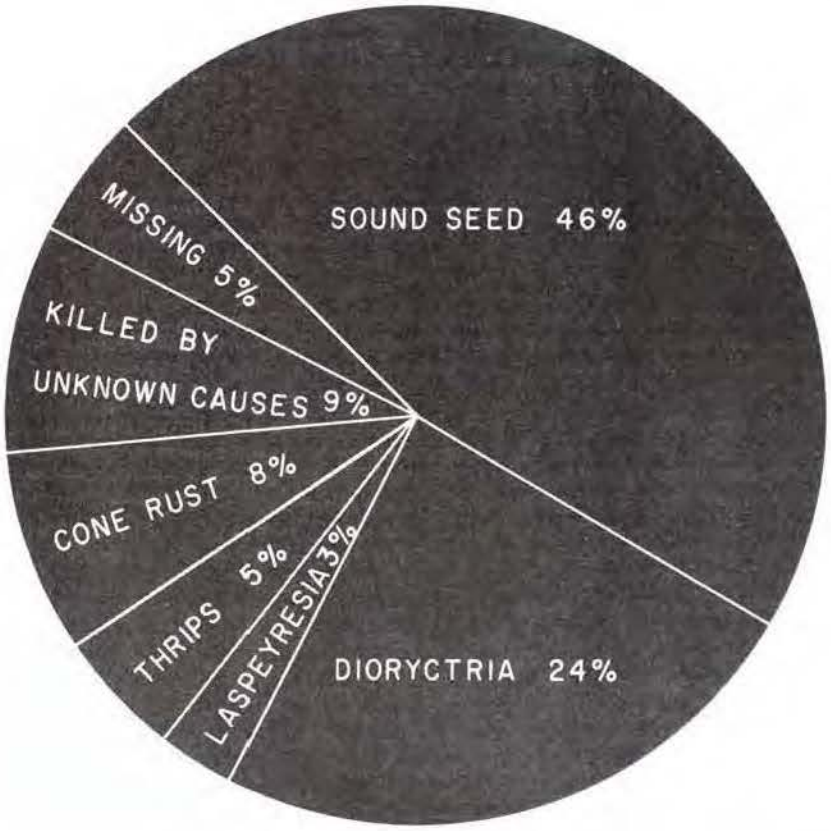
The continuous rearing of tip moths is being attempted. Insect- and lightproof-cages were constructed with a temperature control room in the Eastern Tree Seed Laboratory. This room is maintained at the mean daily maximum and minimum temperature and day length for the last week in June at Macon, Georgia.

A cheap technique for collecting emerging adults was developed. Large kraft paper bags were filled with infested tips. The opening of the bag was crimped around a Mason or fruit jar and wrapped with masking tape around the paper. Thus, the jar can be screwed out of the paper, the moths collected, and the jars screwed in for the next day's emergence.

Collecting a tip moth for oviposition and species isolation in the insectary.

During 1961, five insectaries were built for isolation of tip moth species.

Insects Destructive to Flowers, Cones, and Seeds of Pine



Slash pine seed losses were determined for 7 open-grown 15- to 20-year-old pines near Olustee, Florida, by tagging and frequently examining several hundred flowers and cones. Since thrips sometimes kill as high as 20 percent of the female flowers, and cone rust losses may approach 100 percent in some years, the losses from insects and disease in 1961 would be considered only moderate. Information about insect-caused seed losses will be useful in evaluating the economic benefits obtained by chemical and biological control methods in seed orchards and seed production areas.

Until 1960, damage to pines by thrips was thought to be confined to needles alone. Observations in 1960 at Olustee, Florida, and further confirmed in 1961, showed thrips capable of inflicting damage to as much as 20 percent of the flowers and conelets of slash pine. The insects feed on both scales and bracts of flowers and conelets, leaving tiny, barely visible punctures and abrasions marked by beads of resin. Severe injury and death of flowers and cones often occur.

Dioryctria spp. coneworms are among the important insects affecting seed crops of slash and longleaf pine. In A, Dioryctria larvae killed the young cone on left, then attacked the entire growing tip. In B, a sectioned cone illustrates how Dioryctria often cause total loss of seed in attacked cones.

During 1960-1961, fusiform rust cankers on slash pine were collected at monthly intervals to determine the prevalence of Dioryctria spp. coneworms in this canker habitat and to compare seasonal occurrences with those in cones. In C, dried resin (outlined in white) shows effect of Dioryctria attack on a fusiform rust canker. Only D. amatella (D) was consistently common in the cankers. Cankers were much less heavily infested during the summer when second-year cones were a common host material.

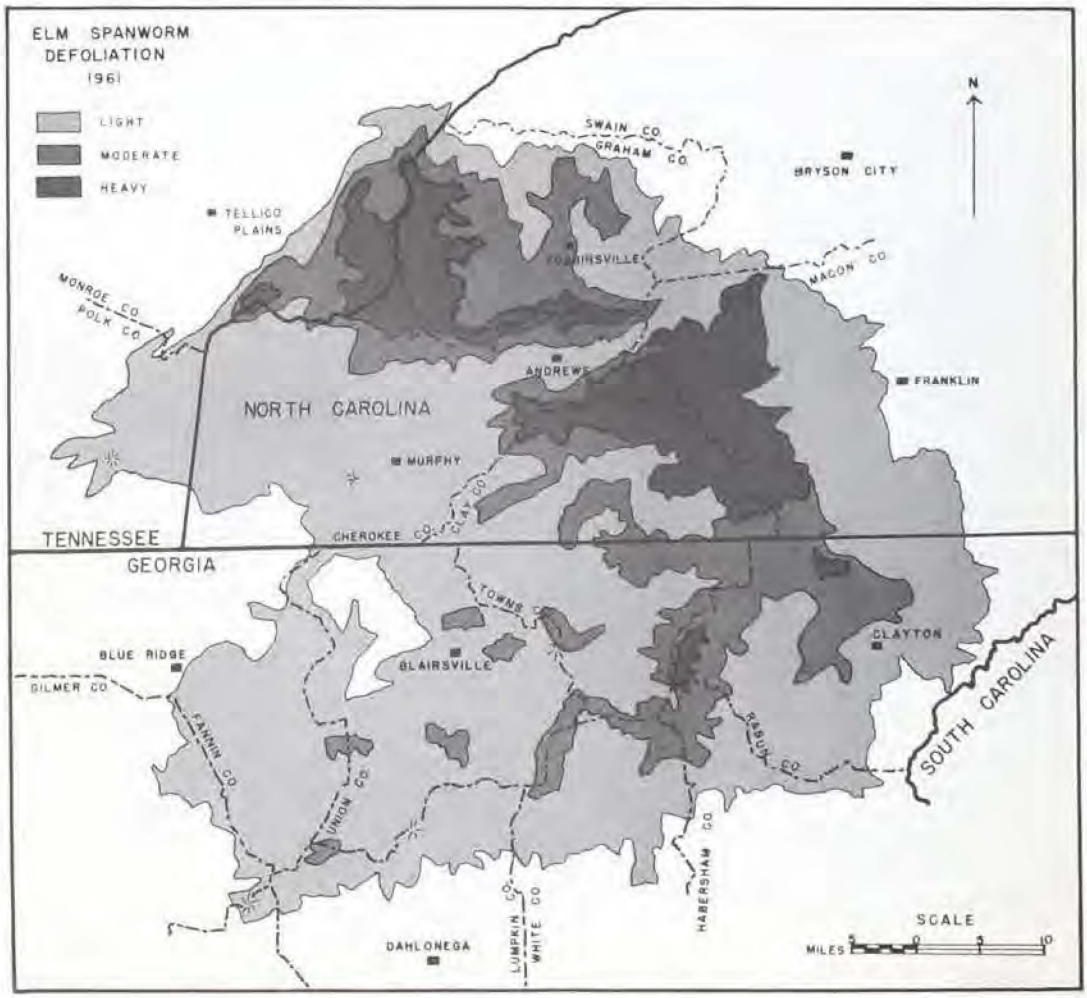
Elm Spanworm

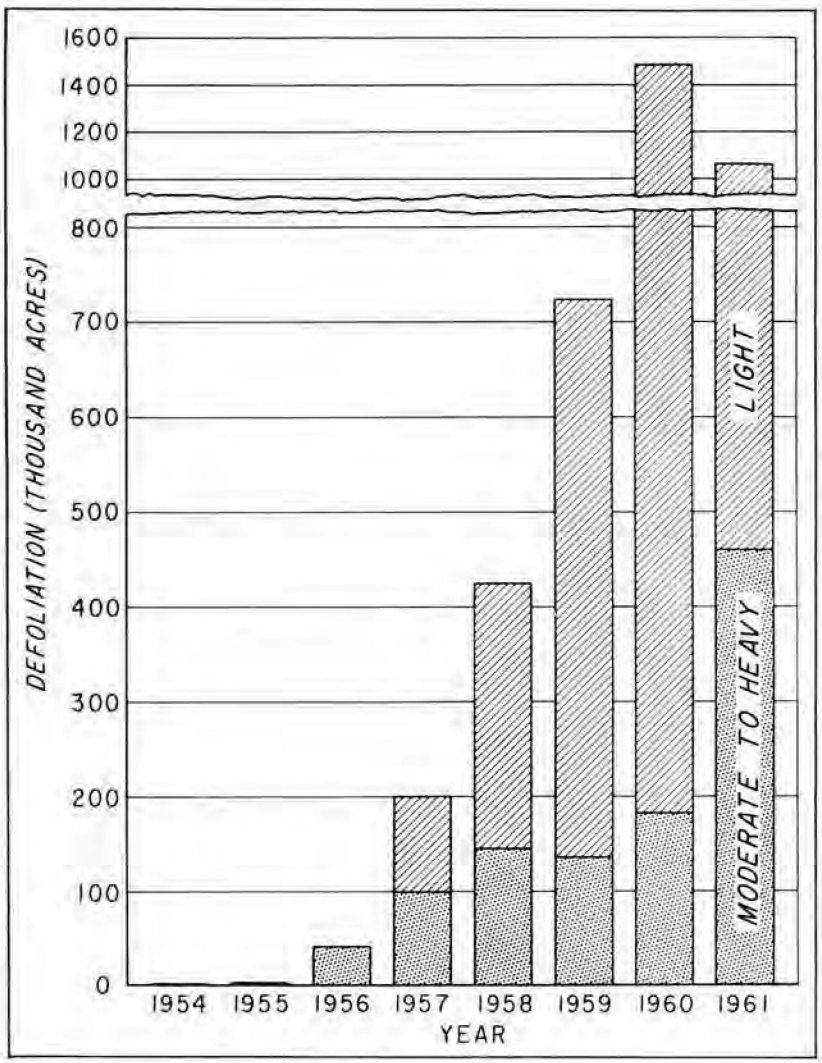
Current analysis of the natural control factors indicates that parasitism and predation have thus far been unable to prevent the infestation from extending into new areas, even though each year brings at least one or two new additions to the spanworm parasite-predator complex in the Southeast. These include such diverse groups as hymenopterons, dipterons, carabids, hemipterons, and spiders. In many cases, however, both parasites and predators are important in modifying the intensity of the infestation.

Similarly, adverse weather conditions have done little to impair the progress of the spanworm. Protracted periods of subnormal temperatures and excessive moisture during larval development, however, often create situations suitable for the growth of localized "pockets" of disease. Efforts are being directed toward securing and isolating pathogens from diseased spanworm populations as they are detected, as well as from closely related insects throughout the United States and Canada.

Elm spanworm larvae.

The elm spanworm infestation in the hardwood forests of the southern Appalachians is unusually persistent. Eight summers have elapsed in which the spanworm has affected annually increasing acreages.





Annual elm spanworm defoliation, showing acreages of light (line shading) and moderate to heavy defoliation (dot shading). This continuing trend gives only slight indications of diminishing. During the early part of July, elm spanworm moths were reported from outside the infested areas: in Knoxville, Tennessee, in the northeast; Griffin, Georgia, in the southwest; and Charlotte, North Carolina, in the east. Egg-carrying females were also collected in several localities outside infested areas.

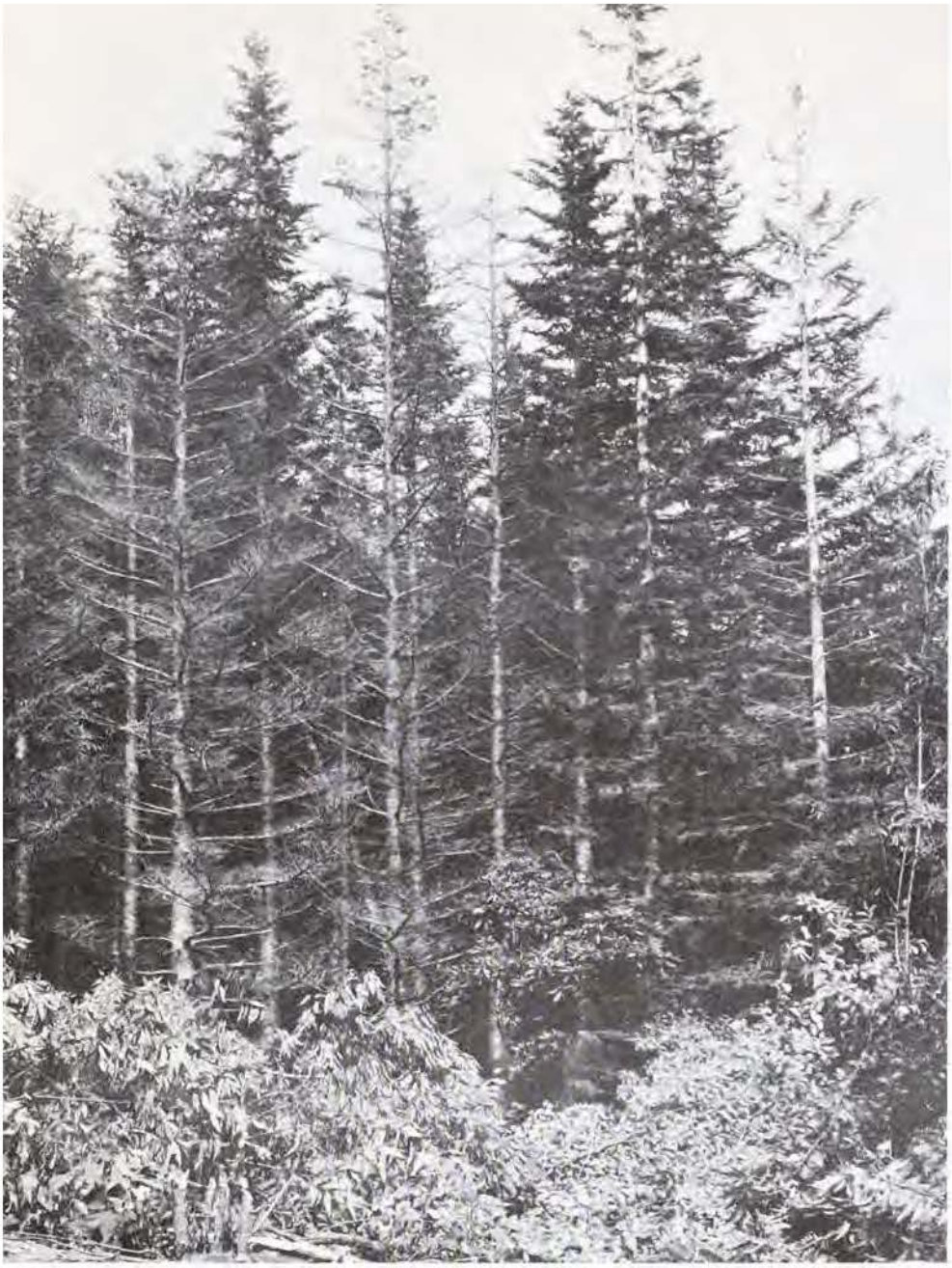
Balsam Woolly Aphid

The balsam woolly aphid, *Chermes piceae* (Ratz.), was detected on Mt. Mitchell, North Carolina, in 1957. Since then thousands of Fraser firs have been killed annually. Damage trend plots in 1961 revealed an 8½-percent increase in the number of trees infested and a 7½-percent increase in the number of trees killed over 1960. In some areas 100-percent mortality of fir has already occurred.

We have determined spray formulations of various insecticides that will control the aphid and allow trees to recover from damage. Because the cost of spraying is high, however, such control is limited to high-value trees.

On forest land the use of biological control offers considerable promise for reducing aphid populations below the tree-killing level. Since the aphid was introduced into this country from Europe, efforts have been made by the Agricultural Research Service of the U. S. Department of Agriculture, the Commonwealth Institute of Biological Control, and the Research Branch of the Canada Department of Agriculture to find predators that might effectively control the aphid. Not only Europe but also Japan, India, Australia, and Pakistan have been searched for predators feeding on closely related species of aphids. Small numbers of these predators have been released on Mt. Mitchell for study to determine their ability to adapt to the environment and to evaluate their effectiveness in controlling the aphid.

Releases of two of the most promising predator species were begun in 1959. Since then four new species were introduced in 1960, and 11 additional species in 1961. Recoveries this year indicate that three of the six species released in 1959 and 1960 have become established.



Attack by the balsam woolly aphid has produced dead and dying Fraser fir on Mt. Mitchell.

Pine Chafer

Recently the pine chafer, *Anomala oblivia* (Horn.), has caused serious defoliation to southern pines. Infestations have been reported near Waycross, Georgia, and near New Bern and Bolton, North Carolina. The infestation in the Bolton area was first reported in 1958 and persisted until 1961, when excessively wet conditions caused populations to decline. In other areas populations persisted for a single season and then disappeared.

Insect Surveys

Forest insect survey, an integral part of the Division's responsibility, was transferred to the Pest Control Section, Division of State and Private Forestry, Region 8, U. S. Forest Service, Atlanta, Georgia, at midyear. This action terminated the Station's responsibility for forest insect detection, appraisal, and control efforts begun under the former Division of Forest Insect Investigations, Bureau of Entomology and Plant Quarantine, in December 1949.

FIRE WEATHER AND FIRE DANGER MEASUREMENTS

Threshold Relative Humidities

Threshold values of relative humidity for large fires in Georgia were determined for 10 years of data (fig. 11). Seventy-seven percent of the large fires occurred when the reported relative humidity was 25 percent or less. The search for improved methods of forecasting occurrence of low relative humidity will continue. In the majority of low relative humidity cases studied (6 years' data), the dry air moved from colder areas to the north or west, either as a gradual advection with a moving pressure system or more rapidly following a cold front. While subsidence inversions reach the surface in the Southeast in only a small percentage of the days, the resulting abrupt drop in humidity can have an explosive effect on going fires.

Fire-Weather Forecasting

Application of fire weather forecasts (routinely prepared at the Fire Laboratory by an assigned Weather Bureau meteorologist) to other forestry problems is finding increasing value. For example, spraying for prevention of fusiform rust was found necessary only if prolonged periods of high humidity were expected.

The twice-monthly fire-weather interpretations of the Weather Bureau's 30-day outlook, prepared as a research study for over three years, were distributed to nearly 1,000 foresters in the Southeast during the near explosive fire-danger period from mid-October through early December. These interpretations will not be distributed routinely but only during critical fire situations.

Two Years' Analysis of Fire Data in Georgia

The second recapitulation of fires and acres burned in relation to measured fire danger has been completed for Georgia. Results confirmed conclusions drawn from the report on last year's data.

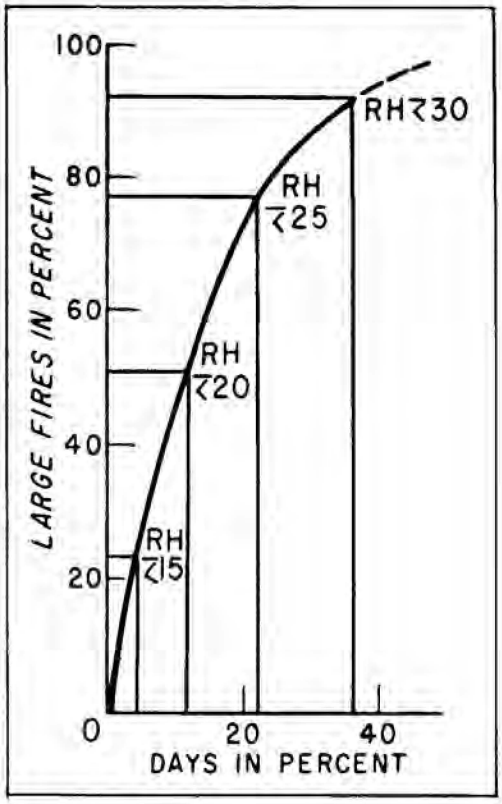


Figure 11.—Cumulative percent of large fires in Georgia versus cumulative percent of days within humidity classes (10 years).

Statewide and in each district individually except one, 1960 trends of number of fires, acres burned, and acres per fire vs. the derived burning index fitted more closely the expected curve than did the 1959 trends.

There were 30 percent more fires in Georgia in 1960 than in 1959. However, the 1960 fire weather was 27.5 percent more severe than the previous year, indicating that prevention effort, as reflected by occurrence rate, was about equally successful both years (table 11). Statewide, fire suppression effort in 1960 also appeared to be at least equal to the 1959 effort. The number of acres burned increased 23.5 percent, but was more than offset by the 27.5 percent increase in fire weather severity.

Table 11. --Comparative fire severity ratings for the years 1959 and 1960, Georgia

Year	Fires	Burned	Fire weather rating 1/	Occurrence rate 2/	Burned area rate 3/
	Number	Acres	Units	Number	Acres
1959	6,422	50,929	1,709	175	1,386
1960	8,335	62,948	2,180	178	1,343

1/ Total units of burning index for the year.
2/ Fires per 1,000 units of burning index per million acres protected.
3/ Acres burned per 1,000 units of burning index per million acres protected.

Uses of Fire Danger Ratings

A compilation of possible uses and applications of fire danger measurements was completed during the year. Much has been written on the location, operation, and maintenance of danger stations but, until now, only fragmentary published information has been available to the fire control manager on the many uses of danger ratings. The derivation of burning and buildup indexes and their significance were described and illustrated. Uses of danger ratings in preparedness and prevention planning, as guides to dispatching, and for evaluating the success of prevention and suppression effort were covered. Of particular interest is a detailed description and example of an electronic computing method for forest fire and fire danger records.

Upper Air Research

The theodolite upper air research studies have continued in 1961 on selected situations where erratic winds could be anticipated. These included thunderstorm and convective heating situations, frontal passages, and cases when subsidence or descending motion was anticipated. These situations, though numerically infrequent, have been associated with many large fires in the past. Wind speeds from single theodolite observations are recognized as much too high in cases of abnormally low pilot balloon ascent rates and too low in cases of abnormally high ascent rates. This dictates the use of the much more tedious double theodolite system for research purposes. Over three hundred sets of both double and single soundings have been taken at the laboratory, and at least a dozen cases analyzed, showing errors so great in the single system that correct interpretation was impossible. As an example, one of several dry cold fronts passing through Georgia during the spring fire season was selected. On March 16, 1961, the front moved from Chattanooga, Tennessee, to Alma, Georgia, between midnight and noon. The upper air wind sounding at the Southern Forest Fire Laboratory at 12:55 (fig. 12A), about six hours after frontal passage, shows wide differences between the single theodolite (A and B) wind speed observations and the double theodolite observations worked up from the same data. The single theodolite data indicate a marked low-level jet of over 25 m.p.h. from 200 to 500 meters and a 35 m.p.h. jet at 1,000 to 1,100 meters. The more accurate double theodolite sounding shows neither jet maximum but indicates a massive downdraft coincident with the jet areas. This downdraft maximum was over 6 m.p.h. Single theodolite observations taken at 13:07 (fig. 12B), just 12 minutes after the earlier release, would indicate a different wind structure aloft. There is no jet evidenced on the later soundings and excellent agreement between single and double observations is apparent. Preliminary analyses of several cases of this type have indicated that the Z-shaped profile on the single pilot balloon soundings is reason to suspect a "false" jet rather than a true phenomenon.

Case Study of a Medium-Intensity Wildfire

The case study method, combined with analytical work, continues to be one of the most effective methods for studying large fire behavior. Observing teams from the Fire Laboratory documented three large wildfires and two prescribed burns during the year.

The medium-intensity Lagoon fire of April 25, 1961, in coastal North Carolina is of particular interest because one single factor, low fuel volume, appears to have prevented a blowup from occurring. Other factors were conducive to extreme fire behavior.

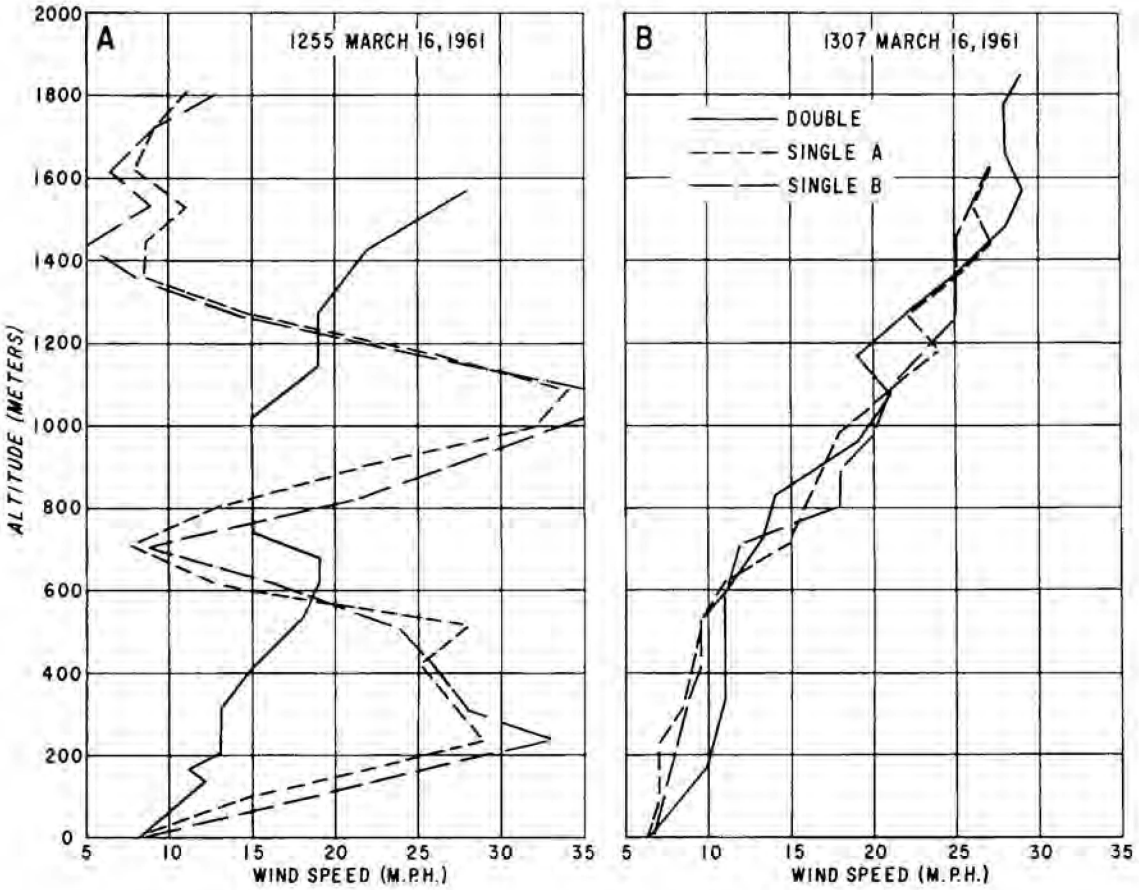


Figure 12.—Plotting of pilot balloon soundings taken 12 minutes apart show differing wind structures. A illustrates "false" jet reading; close agreement between single and double pilot balloon soundings in B would seem to indicate true picture of structure.

Topography in the area is undulating, with low sandy ridges separated by organic bays. The understory fuel type on the ridges was wiregrass-gallberry weighing 4.5 tons per acre. The overstory was longleaf and slash pine. Eight tons per acre of gallberry and sweetbay predominated in the bays; the overstory was a mixture of swamp hardwoods.

The fire escaped from a land-clearing burn about 10 a.m. and spread rapidly before a steady 15 to 20 mile per hour southeast wind but there was no blowup. The major run, between 11:15 a.m. and 12:30 p.m., traveled 2½ miles and burned approximately 1,500 acres. Rates of spread varied considerably, and were faster on the ridges and slower in the bays. The air observer reported scattered spotting up to 750 feet ahead of the flame front directly in line with the direction of fire spread. Small whirlwinds 2 to 3 feet in diameter were observed in the head of the fire. The fire was controlled about 5 p.m. after it had burned into the wetter portion of a large swamp and the wind speed had decreased. Aerial attack on the hot spots and flanks with water and chemicals was effective in the late afternoon.

Conditions at 2 p.m. were: burning index 45; buildup index 69; fuel indicator slats 3.1 percent moisture; and wind 17 miles per hour. In addition, there was an adverse wind profile (fig. 13) over the fire area. Taken together, these measurements indicated severe burning conditions. However, the fire did not blow up. It spread rapidly and burned hot but did not exhibit true blowup characteristics. The smoke column showed very little vertical development and no long-distance spotting was observed.

Fuel volumes on the ridges were light (4.5 tons per acre) and the heavier fuels in the bays were only partially consumed (average 2.3 tons per acre) because of the wet soil condition. These volumes apparently are near the minimum for supporting a blowup fire when conditions are otherwise conducive.

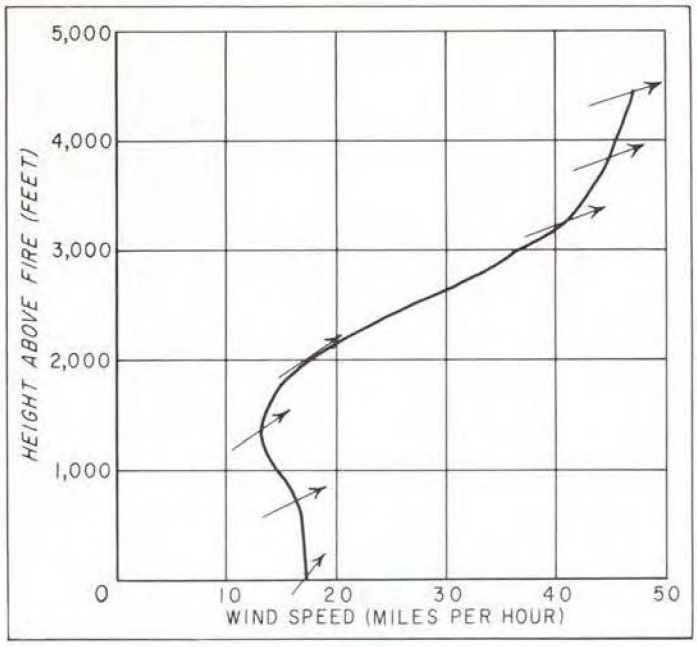
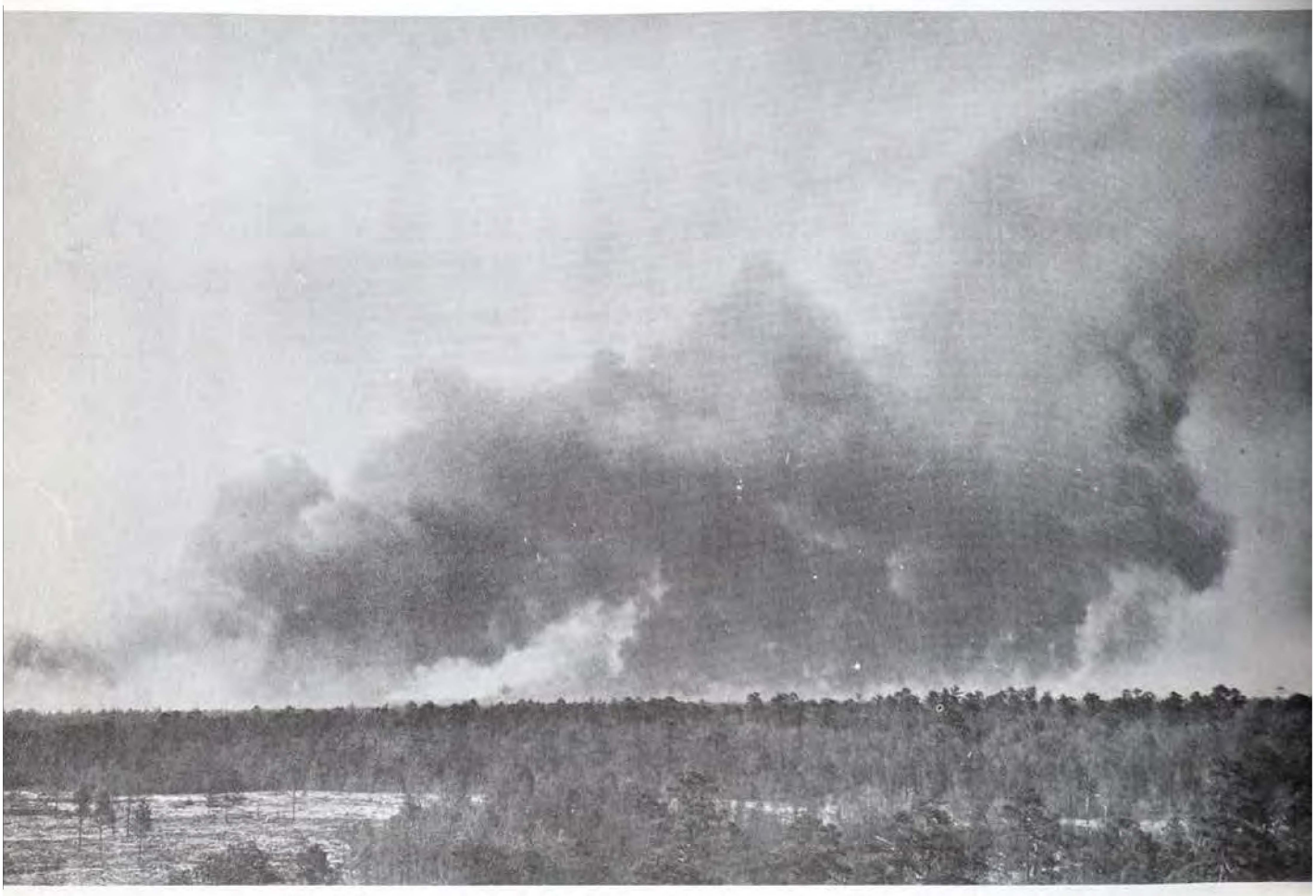


Figure 13.—Wind speed and direction taken near the fire area. The profile was classified adverse.



Convection column above the Lagoon fire. The lack of vertical development and the acute angle between the top of the smoke and the ground are characteristic of a lower-intensity, wind-dominated fire.

A sand ridge area following the fire. One-hundred percent of the 4.5 tons per acre of wiregrass, gallberry, and litter was consumed. Some leaves and needles burned also.

FIRE ENVIRONMENT

Convection Research

The story of blowup fires is the story of convection. Thus, an understanding of these fires depends considerably on the progress in convection research. The convection patterns over high intensity fires have many complex forms which depend on the intensity of the fire, the speed of both the surface and upper winds, stability of the atmosphere, and topographic features. One of the most complex convection patterns, both in its physical structure and process of formation, is that of the fire whirlwind. Because of its fire behavior significance and because it can be readily produced on a model scale, the fire whirlwind has been selected as one of the convection patterns for intensive study. During the past year at the Southern Forest Fire Laboratory, model fire whirls ranging from a few inches to 11 feet in height have been produced in specially designed convection chambers.

By means of energy equations it is possible to compute the approximate velocities developed in the whirlwind. The horizontal component of velocity comes out about 25 or 30 miles per hour and the rate of rotation of the inner tornado-like funnel about 6,000 to 7,000 revolutions per minute. More surprising is the high updraft velocity of about 50 miles per hour which may be very significant for the behavior of full-scale whirls. Reports that tornado-like whirlwinds on high intensity fires have lifted logs 8 or 10 inches in diameter and twisted off large trees do not, therefore, seem unreasonable.

There are two other features of the model whirlwind that may be significant for the behavior of full-scale whirls. One is the rapidity with which the whirl forms following a relatively slow development of a circulation pattern in the surrounding air. The other is a threefold increase in the burning rate in the alcohol liquid fuel pool that takes place when the whirlwind forms.

A model fire whirlwind over a 4.7-inch pool of burning denatured alcohol. Flame height of this whirlwind was 9 feet and the diameter of the whirl near the base was 1½ to 2 inches. The diameter of the inner tornado-like funnel was ¾ inch. The front half of the lower part of the convection chamber is transparent plastic.

A closeup view of the lower part of the fire whirlwind showing the inner tube or tornado-like funnel and the outer flames that spiral steeply and rapidly upward.

Earlier crib fire tests with several species indicated that white fir and sugar maple produce a continuous curve for the rate of spread as a function of specific gravity for a given moisture content. Using white fir and sugar maple as fuels, tests were made to determine the effect of specific gravity on rate of spread for seven different levels of moisture content (fig. 14). The results indicate that rate of spread increases very rapidly with decreasing moisture for specific gravities less than 0.45 and moisture contents less than 10 percent. Since litter, bark, moss, grass, leaves, and partially decomposed wood have specific gravities somewhat less than 0.45 and are the fuels which mainly contribute to the spread of most forest fires, it is apparent that moisture content of these fuels is extremely important in the spread of forest fires. Practical application of the information in figure 14 may be made in the development of the national fire danger system.

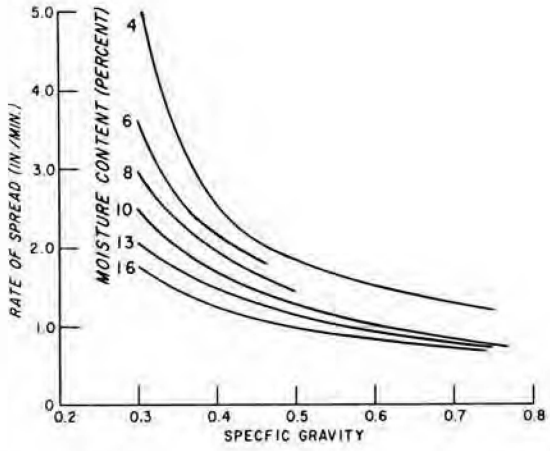


Figure 14.—Effect of specific gravity of wood on rate of fire spread through cribs at different moisture content. (Fuel: white fir ½ inch square sticks at 1¼-inch spacing.)

FIRE MODELS

Combustion Fundamentals

Research on fundamental factors governing uncontrolled fires is continuing at the Southern Forest Fire Laboratory. The steady-state fire model is being used to evaluate the significant variables on fire behavior. The model consists of a crib made of wood burned on a special table in the combustion room. The table and combustion room are instrumented to measure several independent factors, such as radiative and convective heat, height and depth of flame, convection column temperatures, and rate of spread. A detailed description of the model with an illustration is presented in the 1960 Annual Report of the Station.

Measurements of height of flame and depth of flaming zone were made of all the crib fires burned under varying specific gravity, fuel size, and moisture content conditions. The ratio of flame height to flame depth was calculated for each fire. A functional relationship for the ratio L/D with a dimensionless number, V^2/gD, called Froude's Number, was established (fig. 15). The basis of the correlation is that the flame is a diffusion flame so its height should be determined by the flow conditions for any one fuel-air system. With the flame temperatures assumed to be the same for the different fires, this gives L/D a function of V^2/gD, where V is expressed in pounds of

solid fuel per square foot per second leaving the fuel bed as combustible gas at the base of the flame, and g is the gravitational constant or 32.2 ft./sec.^{2}. V^2/gD is dimensionless when V pounds of fuel is converted to volume of combustible gas. V is comparable to fire intensity or rate of combustion per unit area. A practical application of the relationship to field fires would be for estimating fire intensity on sections of a fire front from estimates of height and depth of flame.

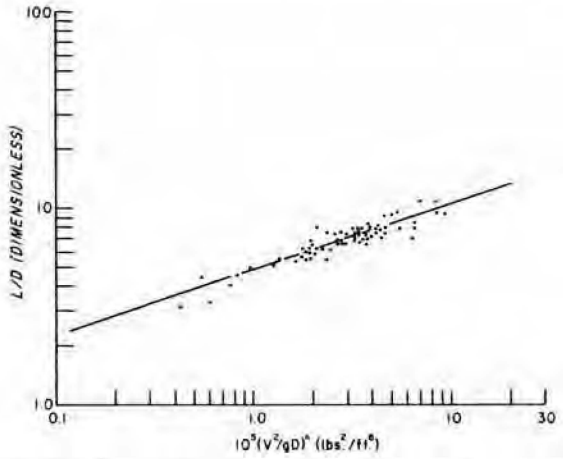


Figure 15.—Ratio of flame height to flame depth, L/D, as a function of the weight of fuel burning per unit area, V, and flame depth, D, for crib fires.

The measurements of the depth of flaming zone for each crib fire burned were divided by its rate of spread to give residence time. Residence time is defined as the time during which a fuel particle resides in the flaming zone. It was found that residence time, Tr, is proportional to the product of the 3/2 power of stick size, d, the specific gravity of wood, S, and the ½ power of moisture content, M (fig. 16). A possible application of this relationship would be in classifying natural forest fuel types. From a measured value of residence time on a field fire an equivalent value for the product of $d^{3/2}$ S $M^{1/2}$ could be determined for a given fuel type from figure 16. Residence time may be determined by using a stake, or some natural identifying point, and a stop watch to measure the time required for the flaming zone to pass a point on a fire front.

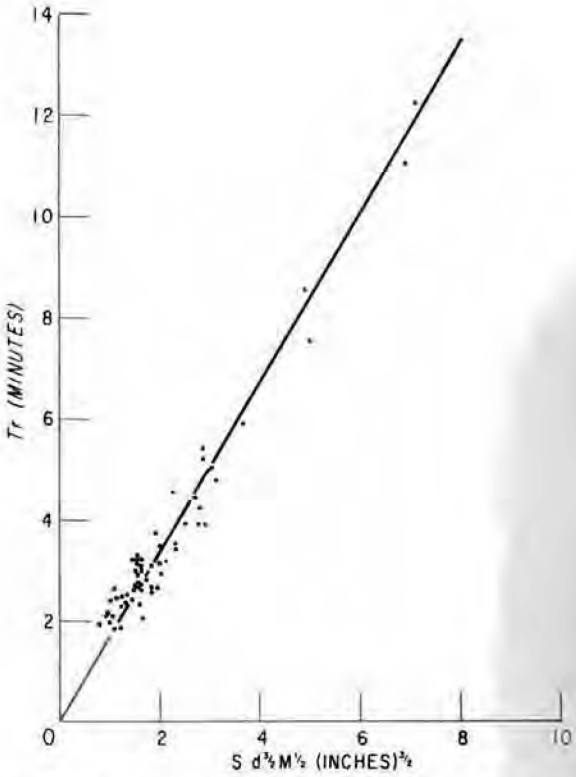


Figure 16.—Residence time, Tr, of crib fires as a function of specific gravity, S, stick size, d, and moisture content, M.

FIRE CONTROL

Sand Casting

More effective ways of suppressing forest fires are still being sought. Anyone who has ever fought a forest fire has, at one time or another, used soil as an extinguishing agent or for mopup. Controlling large fires with soil, however, has never been feasible, primarily because it is difficult to move large quantities in a short period of time.

In 1961, a sandcasting machine developed in Michigan was tested in some of the more hazardous fuels in the Southeast to evaluate the use of sandy soil as an extinguishing or retarding agent. This machine, an experimental prototype, was capable of moving 2.8 cubic yards of soil per 100 feet of line, casting the material as far as 100 feet. On direct attacks, the soil (and the water it holds) extinguished hot fires. On indirect attacks, sand cast lines drastically reduced and often stopped the rate of spread of surface head fires. The resulting trench served as an effective barrier against further spread of those fires able to pentrate the sanded zone. There are, of course, certain limitations in using a direct sand cast attack on the head of intense, fast-moving fires. The heat generated by such fires prevents men and ground equipment from getting in close enough to make an effective attack and the possibilities of equipment failure severely limit safe operation. As a result, indirect attacks show the greater promise at this stage of development.

The Michigan Sand Caster, Model II, is powered by a 130-horsepower engine and pulled by a small crawler tractor. As the machine is towed forward, a stream of earth is cast to one side, leaving a saucer-shaped trench about 26 inches wide.

Diurnal Weather Changes

An analysis of weather records for the past two years indicated that on days with minimum relative humidities of 30 percent or less, coinciding with large fire occurrence, there were consistent differences in wind speed, temperature, and relative humidity between daytime and nighttime hours (fig. 17). Wind speeds and temperatures were lower and relative humidities higher during the night—conditions favorable from a fire fighting standpoint. On large fires in the Southeast, therefore, experienced nighttime fire crews may make possible faster and more effective control.

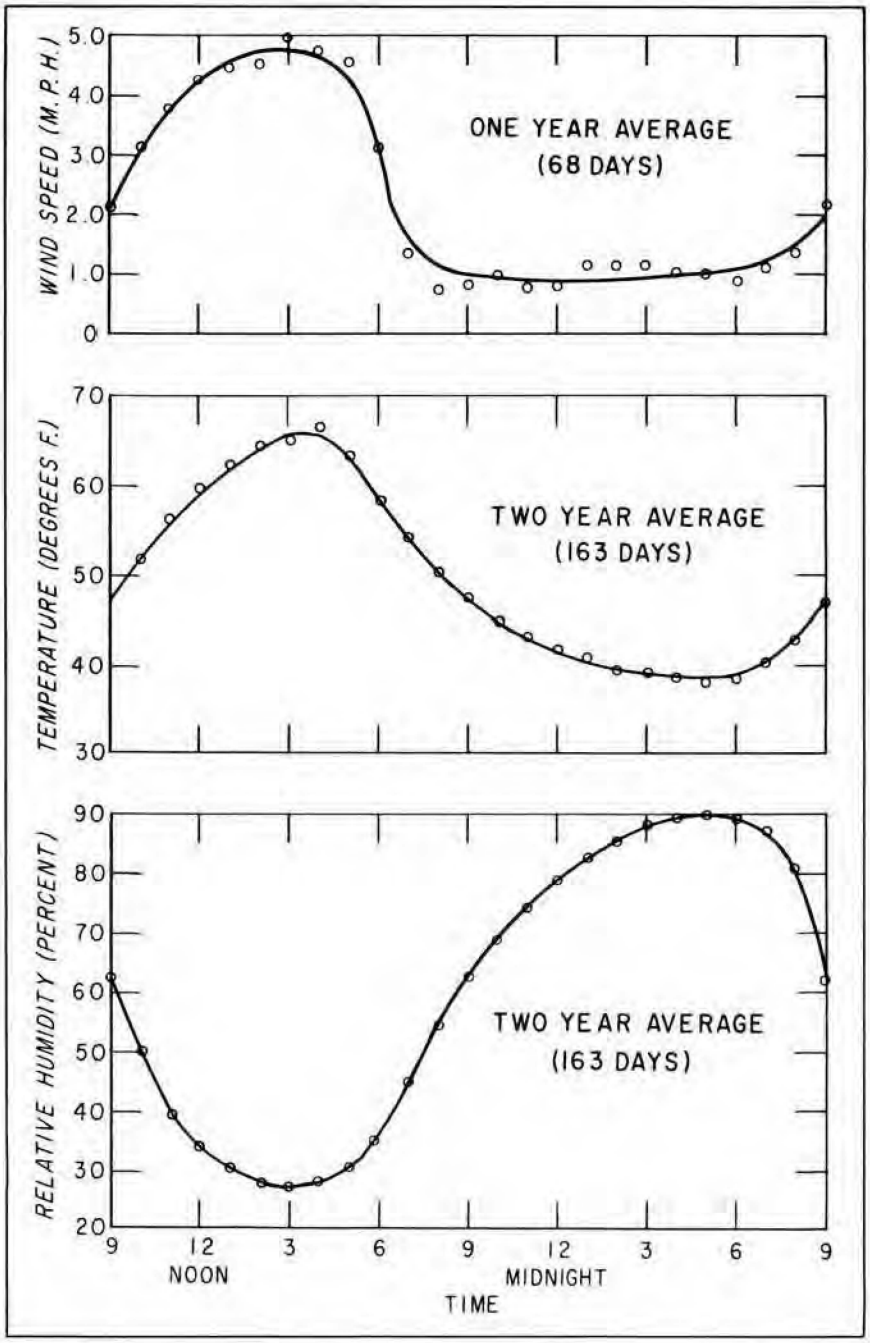


Figure 17.—Diurnal changes of relative humidity, wind speed, and temperature by hourly averages for the months November through May on days with a relative humidity of 30 percent or less.

Florida fire-fighting tanker in action.

FIRE USE

Prescribed Burning

Properly prescribed, fire can accomplish planned benefits in the management of forest land. Periodic winter backfires have generally been considered the best fires for rough reduction in the coastal plains. Preliminary investigations, however, have shown that other firing techniques and other burning periods may actually offer additional possibilities for the use of fire in forest management practices. Strip head fires, for example, have produced higher temperatures than backfires and consequently are usually more effective in controlling undesirable species. Followup burns at a crucial stage in the regrowth process of fire-damaged plants have shown promise of marked reduction in the rate of regrowth as well as some mortality in heretofore difficult-to-kill understory species.

Although hilly terrain presents some problems that are not common to the flat country, topography itself may be used to advantage in prescribed burning by minimizing the effect of some uncontrollable weather factors—wind being the most important. Test burns on the Hitchiti Experimental Forest north of Macon, Georgia, indicate that summer burns do more damage to undesirable hardwoods and brush species than winter burns, and have shown that upslope strip fires are hotter than downslope backfires. Because of their ease of application and indicated effectiveness, upslope strip fires are being used for all repeat burning trials.

One of the most important "unknowns" to be considered in the use of the prescribed fires on Piedmont slopes has been the indirect effect of fire on subsequent soil movement. Measurements taken with a soil erosion depth gauge on some of the Hitchiti burns verify general observations that soil movement as a result of single winter prescribed fires on slopes of less than 15 percent and in well-stocked loblolly pine stands was not a serious problem.

Upslope strip fires are showing the greatest promise for the use of fire as a management tool on Piedmont slopes.

Moisture Fluctuations in Live Fuel

Contrary to popular opinion, the moisture content of some vegetative fuels like palmetto and gallberry does not change appreciably as a result of drought conditions. Rainfall patterns in southeast Georgia in 1959, 1960, and 1961 varied considerably, but the average fuel moisture percent of live palmetto and gallberry plants sampled twice each year between October 1 and November 15 remained fairly constant. In 1961, for example, only 0.53-inch of rain fell between September 10 and November 15, and soil moisture was well below normal, yet vegetative moisture conditions compared favorably with those taken during the same periods in 1959 and 1960—both relatively wet years.

Bark Studies

Study of the effects of fire on tree stems has continued. Thermal conductivity of bark specimens has been found to increase with density and moisture content. Lightweight pine bark is better insulation than the more dense bark of oak and undoubtedly accounts partly for the fire resistance of southern pines. The thermal conductivity of bark at the fiber-saturation point was shown to be 50 percent greater than when the samples were in an ovendry condition. In the case of inner bark with moisture contents of 100 percent or more, conductivity is increased four or fivefold when compared with ovendry measurements.

WATERSHED MANAGEMENT

As reported last year, the variable water yields obtained after cutting timber stands at the Coweeta Hydrologic Laboratory have led to the conclusion that we cannot hope to predict cutting treatment responses reliably through unit watershed experiments alone, and must use some new approaches. This has been the main theme of recent reports—the latest an article by Hewlett and Hibbert in the September (1961) Bulletin of the International Association of Scientific Hydrology—and it reflects a major shift in the Coweeta program toward studies in depth of the soil-climatic-plant relationships affecting water behavior.

During the year, much of the Coweeta effort as well as the related work in the Piedmont at Union, S. C., continued to focus on soil moisture measurement as a technique for estimating runoff and evapotranspiration loss. Accomplishments include development of useful sampling techniques for measuring soil moisture change while holding errors to desired levels of precision. Soil moisture regimes at Coweeta and Union are now being effectively monitored to depths of 15 to 18 feet despite rocks and other difficulties; and large plastic-covered plots are used to control rainfall recharge, separate loss components, and afford a measure of evapotranspiration in situ from natural timber stands. In developing these techniques for water balance accounting purposes, we are trying, among other things, to determine how deeply tree roots withdraw soil moisture.

One contribution from recent work has been an analysis of some 14,000 soil moisture determinations over a 6-year period showing that about 18 inches of moisture (22 percent by volume) remains in the upper 7-foot profile during the driest part of an average growing season. Since this is some 6 to 8 inches above wilting point, it would seem to confirm that Coweeta vegetation on deep-well-drained soils seldom if ever suffers from true drought.

Neutron moisture metering equipment has been in use about 4 years at Coweeta and Union and has afforded a real breakthrough in soil moisture measurement. Since there remain operating difficulties, an important event in August was a 1-week symposium at Coweeta in which experienced technicians from all sections of the country compared results, appraised equipment and methodology, and recommended improvements.

One of the year's highlights was a start on new research at Charleston, S. C., to improve coastal plain wetlands for timber growing and other purposes. The wetlands cover approximately 20 million acres of coastal plain from Virginia to Florida. Some companies are testing ditches to increase productivity.

But perhaps the most intriguing finding of all at Coweeta in recent years is evidence that slow drainage from unsaturated soil profiles is sufficient to sustain and account for base flow of small headwater streams during dry spells. This research was started about 2 years ago, chiefly because the low water flows and behavior of Coweeta streams could not be explained logically by conventional concepts of groundwater hydrology. Some highlights are presented herewith.

Where Does the Water Come From?

Just how does rainfall become streamflow? Where, and how is it stored, and how fast do stored components move over or through the land mass to reach stream channels? In general, we know that most of the rain falling in the channel runs away immediately, whereas some of the water absorbed by land areas may not reappear for years. What happens in mountain country is always uncertain because of variable relief, the nature and depth of porous water-holding material overlying country rock, and other imponderables. The location and concentration of stored water are important considerations in water management, for these affect its availability for use by man and also the evaporative losses to the atmosphere. In short, what we can do to improve or augment supplies of mountain water depends a lot on where it is located and how fast it is moving.

The force of gravity literally "pulls" water out of the mountains and operates uniformly to move each molecule along a particular pathway to join groundwater or streamflow. Resistance determines the rate of flow; and forest cover, the soil mass, and topography provide the resistance. In humid country where annual precipitation exceeds evapotranspiration loss, the intermittent supply of rain produces a continuously varying rate of outflow as expressed in the stream hydrograph (graphical record of gauge height over time). Hydrologists commonly classify streamflow into two types, depending on the mode and rate of delivery of water to a gauging station; i.e., *stormflow* which runs off within a day or two after rainfall, both as overland and subsurface flow; and *base flow* which continues through and after storm periods and sustains streamflow until replenished by the next rain. Estimation of the two types of flow by hydrograph separation is rather arbitrary at best, particularly as applied to small mountain streams, and is chiefly a matter of subjective judgment rather than precise measurement.

Useful as these concepts have been in explaining and predicting the water responses of large drainages, the mechanics of flow in upstream areas is still poorly understood; and hydrologic procedures afford little help in interpreting stream performance. It may be helpful at this point to outline some rationalizations about waterflows which underlie recent work at Coweeta.

Some Ideas about Storm Runoff and Base Flow

When rain falls on porous forest soil, it enters the ground and either begins to migrate to the nearest stream or is held as "retained" water by the soil particles where, according to theory, it is relatively immobile and hence contributes nothing to streamflow. Whether it migrates or is held in place depends chiefly on the character and wetness of the soil, which in turn is usually related to its depth and position on slope. But rainfall recharge entering the soil on different parts of a watershed does not necessarily have the same degree of mobility. Where it sinks in near a stream and consequently can contribute more to immediate rises in streamflow, it generally will move faster than if it enters the drier slopes and ridges above.

Importance of this relationship is illustrated schematically in figure 18, a cutaway sketch of a mountain watershed. Rainfall influence in producing immediate runoff obviously diminishes with distance from the stream channel. This effect is easier to understand when it is realized that the drainage pattern and stream channel itself were formed under the rainfall-runoff regime peculiar to the area. As soil water moves downward and concentrates, it must finally saturate soil and then surface to make its contribution to streamflow and channel cutting. Subsequent rains deepen or extend the channel, until eventually an equilibrium is established between topography and precipitation.

Under prolonged and heavy rainfall, the stormflow-contributing area contiguous to stream channels may grow wider and wider, depending on the nature and depth of the earth mantle. However, at Coweeta the percentage of total rainfall appearing as stormflow (separated from base flow by the usual hydrograph approximations) seldom exceeds 35 percent. During an ordinary storm, say about 2 inches of rainfall in 24 hours, only 10 or 15 percent will normally be stormflow. As a useful approximation, this percentage can perhaps be assumed to be roughly equivalent to the relative watershed area serving as a primary source of stormflow, although logically, the contributing watershed area must be somewhat larger than this. Figure 19 shows graphically how this relationship might appear; i.e., the deeper the soil mantle the closer the curve will approach a 1:1 relation.

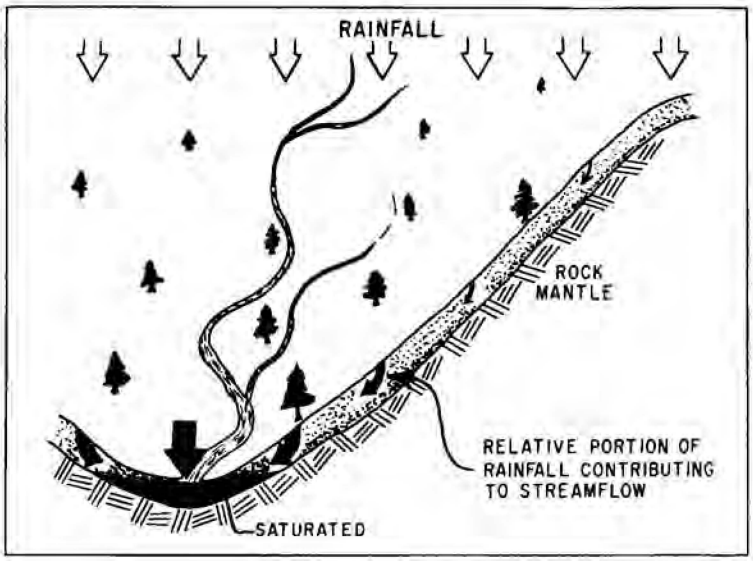


Figure 18.—Schematic cross section of a mountain watershed showing how the relative contributions of rainfall to stormflow vary with position of slope.

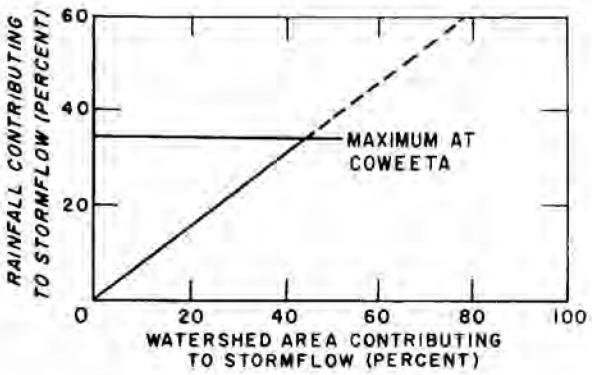


Figure 19.—Speculative relation between stormflow as percent of rainfall and the watershed area from which stormflow comes. The slope of the curve will vary with watershed morphology and condition.

But what happens to the remainder of the water—the portion not reaching stream channels a day or two after rainfall? Of course a great deal of this evaporates or is transpired by plants and hence is lost to streamflow. But while this is happening, a substantial portion continues to migrate downward, eventually appearing as clear springs or streamflow. Thus, the soil mantle is able to moderate erratic rainfall into continuous outflow between storms. The deeper the soil, the better the moderation and the more valuable the watershed as a source of manageable water supply.

In lowlands or wide valley areas, baseflow is partly fed by the slow depletion of free-water, underground aquifers, i.e., the saturated material comprising or lying below a gently sloping water table. But in mountain country such as Coweeta, the soil mantle is sloped too steeply to retain large bodies of groundwater in water tables as commonly pictured. Indeed, considering the steep stream profiles and the precipitous upper valley slopes, it is difficult to visualize a groundwater aquifer big enough to supply streamflow throughout the growing season when current rainfall is generally no more than evapotranspiration loss. To apply groundwater theory to many of the small catchments—some with a thousand-foot range in elevation—free water aquifers would have to be held for many weeks at hundreds of feet of hydraulic potential along stream channels that drop away on 45 percent slopes. All this seems unlikely since the occurrence of extensive groundwater bodies has never been adequately demonstrated at Coweeta, even though some 28 groundwater wells were observed over a 20- to 25-year period.

Coweeta catchments are underlain by massive, water-tight material; and it seems unlikely that deep fissures in underlying rock, although possibly holding some water, are a major source of base flow. Also, the upstream water courses draining steep slopes are remarkably stable and maintain year-round flows which deplete proportionately throughout the upper reaches during dry spells.

Accordingly, it was conjectured that unsaturated soils and moisture in the field capacity range must be supplying most of the dry-weather base flows. The deeply-weathered Coweeta soils are of variable depth averaging about 6 feet in most catchments; and after a heavy rain they can hold temporarily up to 30 area-inches of water (42 percent by volume). Perhaps drainage at almost imperceptible rates from this huge soil mass operating for long periods after recharge might produce enough water to sustain base flows. This had to be verified experimentally.

Variable features of Coweeta streams: A, small, steeply-pitched watercourses draining upper slopes and with year-long base flows; B, entrenched channel traversing narrow valley downstream; and C, fully-formed, gauged stream draining a valley flat below.

Some small Coweeta catchment areas have a thousand-foot range in elevation.

The Coweeta Soil Model Study

A large sloping model simulating a watershed segment was constructed of concrete on a 40 percent slope and filled to a depth of 3 feet with well-mixed, carefully-tamped forest soil so as to reproduce original bulk density. No water could escape except as drainage from an artificial sand-gravel "watertable" maintained at a fixed level by an outlet pipe at the base. 'Tensiometers,, soil thermometers, and other instruments were installed upslope and access tubes were provided for measurement of soil moisture fluctuations by the neutron scattering method. A water level recorder gave a continuous record of drainage outflow from the model.

The first step in operating procedure was to soak the soil column thoroughly with artificial rainfall for about 48 hours to make sure it was fully charged as under sustained rainfall; and then the surface was covered with plastic sheeting to prevent evaporation.

With no additional water added to the 400 cubic feet of soil, the model produced measurable outflow at a continuously diminishing rate for 140 days. As expected, much of this drained off the first 2 days; but precise measurements of outflow and soil moisture demonstrated conclusively that virtually all the flow after that time, for 138 days, was slow drainage from unsaturated soil above the outletted water table. Interestingly enough, this slow drainage, when expressed in terms of the soil volume of a small Coweeta watershed, is in remarkably close agreement with the observed mean dry-weather flow of gauged streams.

The prevailing notion that all free water has drained off when soils reach field capacity must evidently undergo some revision. Field capacity, a somewhat arbitrary value at best, has been reported by various investigators at variable tensions; and within this tension range, the soils of the Coweeta experiment will hold roughly 7 percent of moisture by volume. This is equivalent to about 0.84 inch of water per foot of soil depth, which will be yielded slowly as drainage over long periods until the developing tension halts further movement.

Further illustrating the considerable water yield potential, some soil borings on a 9-acre Coweeta watershed revealed soil depths of from 3 to 10 feet on 90 percent of the area. Using best approximations of field capacity, the soils of this small catchment can store about 18 acre-feet of water or 6 million gallons. Moreover, calculations indicate that drainage of only 1 percent by volume would contribute 200,000 gallons to streamflow—a drainage yield from this small unit equivalent to about a 15-day flow at Coweeta during the winter season.

Accurate field plot measurements of soil moisture change by neutron scattering methods confirm that this slow downward movement of water occurs for many weeks after rainfall. Furthermore, a recent analysis shows close correlation between the annual trends in soil moisture and the base flow of Coweeta streams; and suggests that what is going on in seemingly well-drained soils high on mountain slopes may have a great deal to do with day-to-day streamflow rates. These indications that base flow of mountain streams does not come entirely from extensive underground reservoirs afford important clues for water managers; for some of it, apparently, drains from mountain slopes quite remote from the streams and hence is subject to day-to-day evapotranspiration loss and quite possibly management influence.

Large Coweeta soil model used to verify slow rates of drainage from moisture in the field capacity range. Photo taken of a later run, when in grass cover.

Much Yet To Be Learned About Water Movement

These and other Coweeta experiments are giving some new insights, but application to other mountain areas, other soils, and other climates must await further experience and development of better prediction methods than are now available.

Meanwhile, we can conclude with some confidence that a watershed manager in the southern Appalachians must consider, among other things, the variable distribution of the soil mass in relation to drainage pattern. Evidently, the same practice applied to two different segments of a watershed may have quite different consequences on water yield and on watershed damage as well. For instance, skidding logs which reduces water intake near streams is likely to have a disproportionate influence on stormflow rates and stream channel erosion, whereas the same practice on ridges may do much less damage. On the other hand, the same practice on slopes and ridges may well alter soil water storage relations as well as rate and direction of water movement, and hence may have greater influence on water yields, particularly the low flows.

RANGE, WILDLIFE HABITAT, AND FOREST RECREATION

IMPROVING NATIVE FORAGE

Various practices to improve quality and yields from native range are being studied at Tifton, Georgia, and Ft. Myers, Florida. Burning the range has always been a highly effective means of improving forage quality but produces only short-term benefits. Phosphorus content of pineland three-awn grass in south Florida, for example, dropped from 0.14 percent on freshly burned range to 0.08 percent 7 weeks after burning and to 0.01 percent 1 year later. When cattle, timber, and wildlife are combined in a management program, the nutrient problems are not easily resolved because young trees, particularly slash pine, require the exclusion of fire for at least several years. Accordingly, there is real need to develop methods of improving forage quality without recourse to burning.

Promising results were obtained several years ago in south Georgia when carpetgrass and common lespedeza were broadcast seeded on undisturbed vs. chopped and disked flatwoods soils on an experimental area near Alapaha. Fertilization was at the rate of 30 or 60 pounds per acre of phosphate (P_2O_5) annually, and rates of application were the same for potash (K_2O).

On units where native sod was undisturbed, grazing tended to eliminate all grasses except carpetgrass *(Axonopus affinis)*. Disking practically eliminated the native pineland three-awn *(Aristida stricta)*, Curtiss dropseed *(Sporobolus curtissii)*, and the bluestems *(Andropogon* spp.). Carpetgrass spread until it became the most abundant forage species on all test units, but land preparation speeded its establishment and helped maintain the stands. Very good stands of common lespedeza *(Lespedeza striata)* were obtained with and without land preparation, but extremely close grazing and a severe drought greatly thinned them out. Land preparation plus fertilization greatly stimulated establishment of dogfennel, goldenrod, and other undesirable invaders. Blackberry, too, increased greatly on units that were moderately fertilized and it formed impenetrable thickets where the soil was moist. Gallberry *(Ilex glabra)* and saw-palmetto *(Serenoa repens)* that survived the original treatment persisted throughout the 5-year study but spread little.

In terms of beef production, the land preparation employed in this study did not pay its way. Under both moderate and low rates of fertilization, the net returns were greater from units that were merely fertilized and seeded. Moreover, the net returns probably could have been increased some by permitting the carpetgrass to become established naturally.

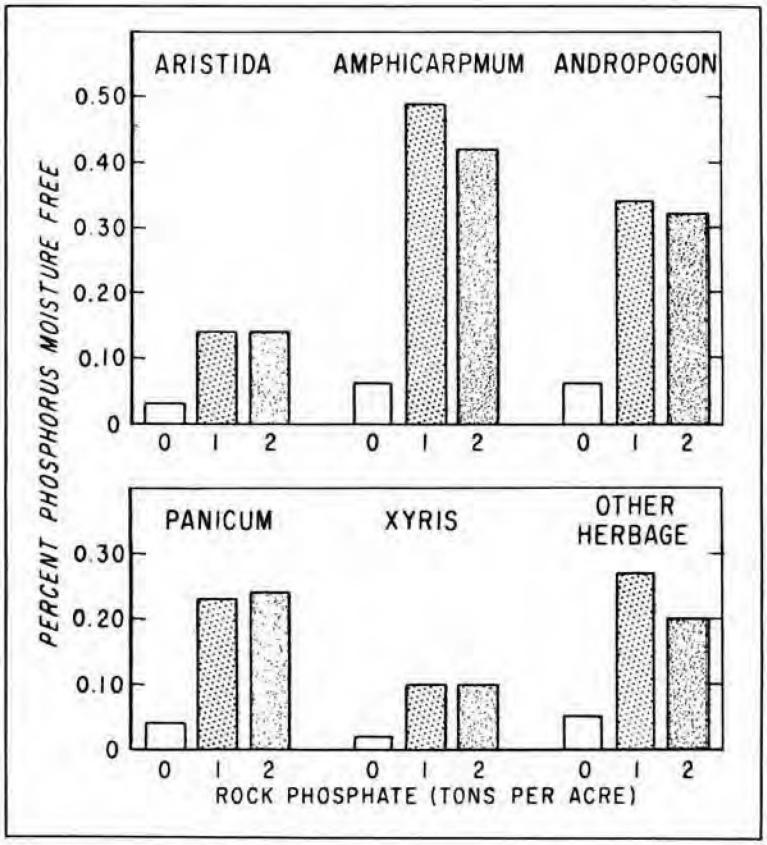
A more recent study in south Florida, involving applications of rock phosphate on native range, has produced extremely favorable responses both in terms of forage and animal use. Treatments included two levels of rock phosphate (1 or 2 tons per acre) applied to double-chopped and unchopped plots on the Caloosa Range, near Fort Myers, in June 1959.

Chopping treatment almost eliminated pineland three-awn and killed 71 percent of the saw-palmetto. A year later, mortality of saw-palmetto had increased to 83 percent. A large number of weed species invaded chopped areas, and carpetgrass was one of the more active invaders.

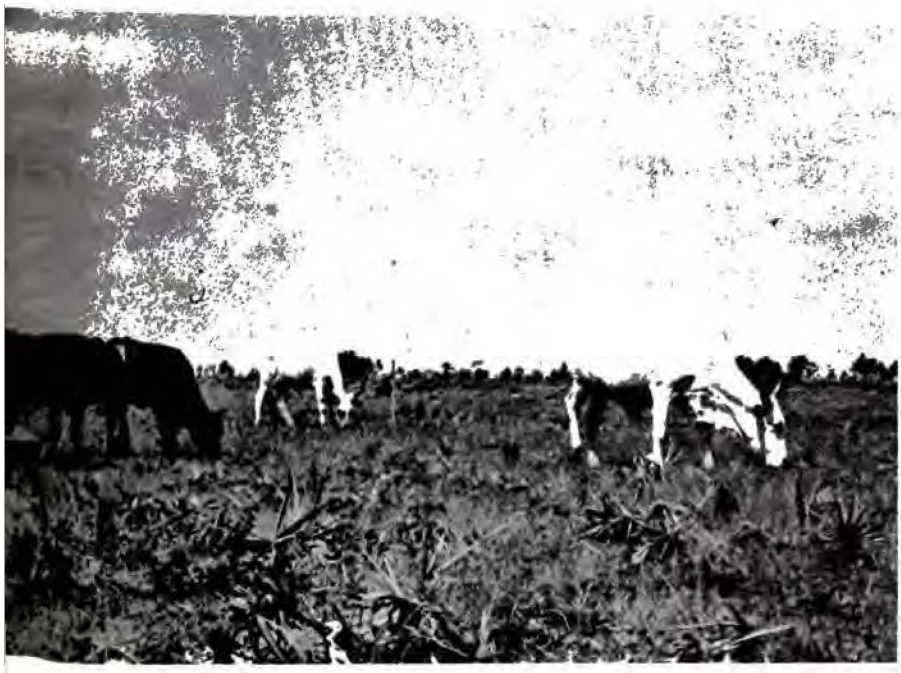
Cattle eagerly sought out and closely grazed the varied and abundant forage that came in on plots treated with rock phosphate. Yields of total herbage increased dramatically. During the first year they were more than doubled on plots receiving 1 ton of rock phosphate per acre; and they increased more than 3-fold on plots getting 2 tons per acre. Chopping treatment, although it influenced herbage composition, apparently had minor effect on forage yield.

Perhaps the most interesting response from rock phosphate application was to increase desirable forage plants. For example, the yield of goobergrass *(Amphicarpum muhlenbergianum)* (highly palatable to cattle year-round) was 3 and 4 times greater at the 1- and 2-ton phosphate levels than on check plots. Adding the phosphorus stimulated prolific seeding of plants, especially the valuable panic grasses, and thus may prove a potent technique for improving game habitat, particularly for quail. The study affords a striking demonstration of palmetto control from heavy grazing induced by fertilization.

Improving native forage on the Caloosa Experimental Range with rock phosphate and double chopping. Above, typical south Florida palmetto-wiregrass range before treatment. Center, after mechanical chopping and 1 ton per acre of ground rock phosphate. Below, one year later, heavy grazing had removed most of the herbage — 3,680 pounds (ovendry) per acre per year.



Phosphorus content of plants growing on areas treated with 0, 1, or 2 tons of rock phosphate in June 1959. Herbage samples were collected a year later.



Cattle preferred and heavily grazed the forage on fertilized plots.

WILDLIFE HABITAT

Progress was made during the year in several cooperative studies of the effects of timber cultural practices on game habitat and other wildlife-silvicultural relationships. Initial vegetation measurements were completed on the comprehensive pine site preparation study in the Florida-Georgia flatwoods with the help of Florida and Georgia Game Division personnel. Also, the second cycle measurements were made in a deer-carrying-capacity study under way cooperatively with the Georgia Game Division, the U. S. Marine Corps, and U. S. Fish and Wildlife Service in an 800-acre enclosure near Albany, Georgia. And in another continuing study, range condition data were obtained and analyzed to assess recovery succession on some badly overbrowsed deer ranges on the Pisgah National Forest.

Deer range inventory work also continued as a phase of the Forest Survey in Georgia. Data from the Piedmont afford a useful comparative index of browse quality in the loblolly and water oak-gum types in Jasper, Lamar, and Talbot Counties. Sampled species were sorted into browse preference classes based on observed deer usage in th Southeast in an effort to determine quality differences between major types.

Although differences between preference classes are highly significant, the totals for all preferred and staple browse foods were only moderately greater in the water oak-gum type. Striking, however, was the high percentage of staple and preferred browse forage in both types.

One of the more widely used habitat improvement practices is that of providing supplemental forage in forest clearings. For a number of years, State Game Commissions have planted old fields and new clearings throughout the southern Appalachians to various pasture forage plants. A new study to observe utilization of several agricultural forage species was installed as a cooperative undertaking with the North Carolina National Forests, the State Game Division, and the Fish and Wildlife Service. The design utilizes two fields with 5 blocks of 8 plots in each, one field being an old bottomland site and the other a new upland clearing. The fields are about 70 miles apart and obviously have separate herds in differing situations. Red clover, ladino clover, Kentucky 31 fescue, shade fescue, tall oatgrass, Oklahoma brome, orchardgrass, and Kentucky bluegrass were sown in plots ½ chain square. Four-by-four-foot square chicken-wire cages 3 feet high were installed in each plot to protect the 3.1 x 3.1-foot forage sampling units.

High nutrient levels and large quantities of palatable forage are supplied by supplemental forest clearings.

Three clippings were made during the summer and early fall (late June to mid-October) on all plots where differences in stubble height, between protected and open areas, exceeded one inch. Utilization on all grass plots was negligible throughout the summer, and these were not clipped. The red and ladino clover plots, however, were heavily used and interim clipping yielded large samples.

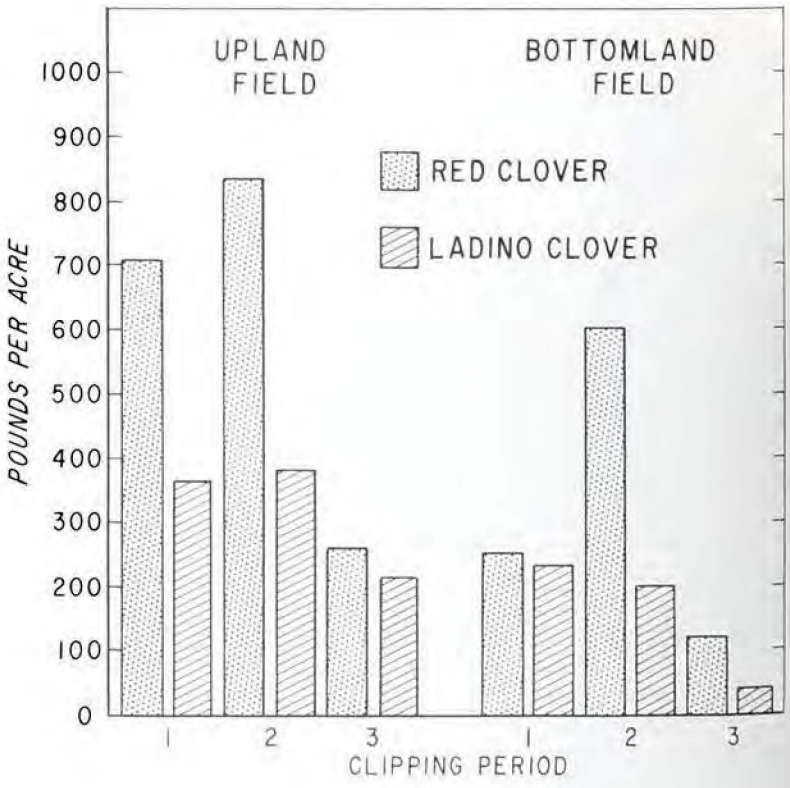
The forage samples were compared on an oven-dry weight basis, and differences between species, between clipping periods for species, and between location were all highly significant. Although unprotected stubble heights were examined for differences between species, the differences were slight and not significant (for ladino and red clover, respectively, the means were 4.83 and 4.98 inches).

From stubble height comparisons, the relative preferences of deer for the two clovers seem approximately equal, since both species were utilized to an average stubble height of about 5 inches. The sampled differences appear to be a manifestation of production. Frequent flooding and a persistent high water table may have retarded production in the bottomland site and accounted for some differences between fields. Those observed between clipping time (midsummer, late summer, and early fall) correspond closely with expected growth periods.

The greater utilization of red clover is not surprising when differences in growth habits are considered. Ladino is low-growing with long repent or creeping branches, while red clover is upright with ascending stems reaching 2 or 3 feet and not only produces more forage but apparently is more easily taken than ladino.

Four-foot-square caged plots protected sample units of eight different grass and clover species in a test for levels of summer use by deer.

Red clover was heavily used, as evidenced by large quantities of forage clipped from protected plots.



Ovendry weights of red and ladino clovers utilized by deer each clipping period on the two areas.

FOREST RECREATION

Financed as a graduate program under a cooperative arrangement with the Virginia Cooperative Wildlife Unit at Blacksburg, a recreation study was launched for sampling widely dispersed activities such as hunting, fishing, hiking, bird-watching, and rock collecting. A unit of approximately 100 square miles on the George Washington National Forest was used for this purpose, and during the period June 15 to September 1, the dispersed uses totalled more than 200,000 man-hours in this one unit. Although data are preliminary, it is now evident that the model tested will have useful applications as an accurate, relatively cheap means of obtaining reliable estimates of these hard-to-measure types of recreation use.

An extensive sampling of developed camping and picnic areas on the Pisgah, Nantahala, and Cherokee National Forests was completed during the year. Forty-two areas with a total of 280 family units were sampled to determine cause and effect relationships and assess the impacts of mass recreation use. Data were collected to characterize the attributes of sampled site, the design and layout features, use loads, and some of the physical and biological effects of use. Findings were analyzed in two ways: First, sampled attributes in plots surrounding each family unit centering on a picnic table were summarized, and regression analysis was performed. Second, all data on condition of trees and shrubs were examined to see whether species differed in relative ability to withstand use impacts. Both analyses turned up much practical information bearing on the selection, management, and rehabilitation of developed sites.

Interviewing a forest visitor to develop sampling procedures for estimating recreation uses.

Forty-two campgrounds and picnic areas on National Forest lands were sampled to assess environmental impacts of heavy recreation use.

Percentage of bare ground, degree of erosion, root exposure, and physical injury to trees are perhaps the best indicators of use impacts. On residual soils, the texture, depth of A horizon, and hydrologic condition (an index of capacity for water intake and storage) apparently govern to a large extent the degree of damage to the site. Effect of overstory canopy is extremely important, and crown closure apparently increases root exposure and erosion by lowering density and vigor of ground cover. Shrub barriers within campgrounds and picnic areas restrict and concentrate human activity. Although protection afforded by shrubs reduces tree injury to some extent, it also contributes to soil exposure and erosion losses.

Particularly interesting is the apparent effect on conifers in the stand; as the conifer component increases, root exposure and percentage of bare ground also increase — undoubtedly associated with the substantial reduction in understory vegetation under coniferous crowns. Aspect also is a factor; and as site productivity improves due to aspect, there is less erosion—again reflecting a better development of ground cover.

Of the various criteria, volume of use per table, as expected, is directly associated with site damage. Months of use is also important, greater damage being associated with the shorter periods of use.

Bared soil, exposed roots, and injured trees provide a quick means of assessing damage. Such areas need immediate attention.

In general, the less productive areas apparently suffer more from human use. Mitigating factors are the soil characteristics, cover types, facility layout, and use loads. This is reflected in the high degree of explainable effect exerted at all sites by position on slope, the conifer component, the percent of high canopy, acres per table, and volume of use per table.

Relative ability of tree and shrub species to sustain or tolerate damage from recreation use came in for special scrutiny. Among conifer species, hemlocks, though they sustain much injury, evidently are best able to withstand heavy use pressures. A tally of the ratio of stumps to living trees afforded one of the better indices of this.

Except for a high degree of disease incidence, largely *Fomes annosus*, white pine shows considerable capacity to withstand abuse. The disease factor, however, is likely to be limiting and makes the species a poor risk.

Of the hardwoods, some species were conspicuously less susceptible to use impacts, both direct injury and secondary disease-insect problems. Hickory, persimmon, and sycamore were notable in this respect. The oaks, and red oak particularly, display a high damage incidence. Black locust, sourwood, and black cherry apparently have less capacity to withstand damaging effects of recreation use and show relatively high levels of insect-disease attack and general decline.

Of the shrubs, only three occurred in sufficient numbers to warrant examination, i.e., rhododendron, mountain laurel, and azalea. All show some capacity to tolerate abuse, but the deciduous azaleas apparently are best able to maintain themselves under heavy use pressure.

Tree species vary greatly in susceptibility to damage and capacity to withstand heavy recreation use. Hickory, persimmon, hemlock, and sycamore were notably resistant to wear and tear.

PUBLICATIONS

by

MEMBERS OF THE STAFF

INCLUDING COOPERATORS

Calendar Year 1961

ADAMS, H. E., and SCHOCH, M. S.
1960 forest fires and fire danger in Connecticut, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, and West Virginia.
(Twelve separate reports containing tables and graphs analyzing forest fires and fire danger.)

ALLEN, P. H.
Florida longleaf pine fail in Virginia. Jour. Forestry 59: 453-454, illus.
(Five-year results show that survival of longleaf pine of local (Virginia) origin best but differences in height growth among sources were not as pronounced.)

ALLEN, P. H.
Natural selection in loblolly pine stands. Jour. Forestry 59: 598-599.
(Natural selection may be quite rigid for growth before artificial selection by forest tree breeders begins.)

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Loblolly pine seed production in the Virginia-North Carolina coastal plain. Jour. Forestry 59: 187-190, illus.
(Preharvest release improved seed production and percentage of sound seed. Stand age and density are important factors affecting seed production.)

AMMAN, G. D.
Predator introductions for control of the balsam woolly aphid on Mt. Mitchell, North Carolina. Southeast. Forest Expt. Sta. Res. Notes 153, 2 pp.
(Summarizes introduction of foreign predators into Mt. Mitchell area during 1959 and 1960.)

ANDERSON, W. C.
A method of appraising pine sawtimber in South Carolina. Southeast. Forest Expt. Sta. Paper 122, 15 pp., illus.
(Prices of individual tracts differ from the average because of variation in volume per tree, distance to mill, and geographic location. These factors are used in a simple appraisal method.)

BARBER, J. C.
Growth, crown form, and fusiform rust resistance in open pollinated slash pine progenies. Sixth South. Conf. on Forest Tree Improvement Proc. 1961: 97-104.
(Significant differences between 8-year-old progenies were found for traits such as height, diameter, rust infection, stem crook, crown width, and natural pruning.)

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(After 4 years, slash and loblolly pine seedlings in Georgia, selected in nursery beds for vigor, were taller than a similar number of control seedlings from the same beds. Rust infection, survival percent, and tree form were about the same for each group.)

BARNES, R. L.
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(The major portion of the radioactivity from labeled adenine was recovered in hypoxanthine and inosine.)

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Studies of ureide synthesis in trees. (Abs.) Assoc. South. Agr. Workers Proc. 1961: 229.
(Results indicate ureide synthesis by purine catabolism and by synthesis from simple molecules with intermediate formation of purines or closely related precursors.)

BARNES, R. L., and NAYLOR, A. W.
Studies on the formation of B-alanine by pine embryos and callus tissues from aspartic acid, spermine, spermidine, and pyrimidines. (Abs.) Plant Physiol. 36 (Sup.): 18.
(Pyrimidine catabolism provides important mechanism of B-alanine synthesis in all pine tissues examined.)

BARNES, R. L., and NAYLOR, A. W.
Utilization of radioactive ornithine by germinating embryos of longleaf and slash pines. Forest Sci. 7: 130-135.
(When DL-ornithine-2-C^{14} is administered to embryos of longleaf and slash pine, C^{14} appears in citrulline and arginine.)

BENNETT, F. C.
Silvical characteristics of southern magnolia. Southeast. Forest Expt. Sta. Paper 139, 9 pp., illus.
(Extent and climate of botanical range, edaphic and physiographic site conditions, reproduction and growth habits, ecology, plant and animal pests, and response to management.)

BERRY, C. R.
Observations on white pine needle blights in Tennessee and West Virginia. (Abs.) Phytopathology 51(9): 642.
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(Evidence indicates that emergence tipburn of white pine is caused by an atmospheric abiotic agent, such as ozone.)

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Extension of range and a new host for Cristulariella pyramidalis. Plant Dis. Rptr. 45(2): 152.
(A fungus that causes premature defoliation of some species of maples was noted for the first time in Asheville, N. C.)

BOIS, P. J.
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(Describes for the layman differences in exterior and interior plywood, including typical glues used and grades available.)

BOIS, P. J.
Sawdust and bark as supplements to Georgia soils. Coop. Pub. Ga. Forestry Comm. and U. S. Forest Serv. Southeast. Forest Expt. Sta. Forest Util. Serv. Release 23, 2 pp.
(Decomposed sawdust or bark can provide humus and organic materials to improve heavy clay soils.)

BOYCE, J. S., Jr.
Symptoms in relation to infection pattern in white oak. Plant Dis. Rptr. 45(5): 386-387.
(Branch dieback and water-soaked leaves of white oaks are good field symptoms in the diagnosis of oak wilt.)

BRENDER, E. V.
Control of honeysuckle and kudzu. Southeast. Forest Expt. Sta. Paper 120, 9 pp., illus.
(Discusses ecology and control of honeysuckle and kudzu in Piedmont Georgia.)

BRENDER, E. V.
Pruning open-grown loblolly pine. South. Lumberman 203(2537): 134-136, illus.
(Loblolly pine should be pruned while trees are small so that early, fast rate of diameter growth is checked, knotty core kept to a minimum, and costs minimized.)

BRENDER, E. V.
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(When managing loblolly pine by clearcutting and planting, long-suppressed saplings should be cut because of slow growth and interference with growth of the new pine crop.)

BRYAN, W. C.
How good are the Piedmont hardwoods? Forest Farmer 20(9): 8-9, illus.
(Major hardwood defects can be reduced with proper management and harvesting, and if stands are given adequate protection from fire and overgrazing.)

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(A pure-culture technique for mycorrhizal synthesis demonstrated mycorrhizal formation by eight fungi in association with roots of southern pines.)

BURTON, G. W., and HUGHES, R. H.
Effects of burning and 2, 4, 5-T on gallberry and saw-palmetto. Jour. Forestry 59: 497-500, illus.
(Best control of gallberry and saw-palmetto was obtained by burning in March and spraying in August with 2, 4, 5-T in water.)

CAMPBELL, R. A.
Silvical characteristics of chestnut oak. Southeast. Forest Expt. Sta. Paper 138, 12 pp., illus.
(Extent and climate of botanical range, edaphic and physiographic site conditions, reproductive and growth habits, ecology, plant and animal pests, and response to management.)

CAMPBELL, W. A.
Eastern tree seed laboratory. Forest Farmer 20(9): 14-16, illus.
(History of seed testing developments in the South and description of services available at Eastern Tree Seed Laboratory, Macon, Georgia.)

CAMPBELL, W. A.
South's new forest pest laboratory. Forest Farmer 21(1): 20, 28, illus.
(Describes facilities and program of new Forest Service biology center at the Research Triangle Park in North Carolina.)

CARTER, M. C., and NAYLOR, A. W.
Metabolism of 3-Amino-1, 2, 4-Triazole-5-C^{14} in plants. Bot. Gaz. 122(2): 138-143, illus.
(Large quantities of substance accumulated in terminal growth as the principal metabolic product of ATA-5-C^{14} in the form of an unknown. ATA itself did not reach the terminal meristem.)

CLEMENTS, R. W.
Air temperature and gum yield. Southeast. Forest Expt. Sta. Res. Notes 168, 2 pp.
(In Mississippi, longleaf pine produced 30 percent of the total yearly gum yield during 8 weeks in July and August. Trees should be worked more intensively in midsummer if streaks were missed early in the season.)

CLEMENTS, R. W.
Profitable gum production from limited-face-height leases. Naval Stores Rev. 71(2): 6-7. Also in AT-FA Jour. 23(11): 12.
(In Mississippi, within the face height limitation of 54 inches, biweekly chipping with 1-inch streaks and 60 percent acid produced 6 percent more gum over a 3-year period than weekly chipping the same face height.)

CLEMENTS, R. W.
Scrape yield from longleaf, slash greater than others. Naval Stores Rev. 71(6): 4-5, illus.
(For longleaf pine the proportion of scrape in total season's yield is 20 to 24 percent; in slash pine 1 to 8 percent. Scrape should be removed from tins as early as August to prevent wastage.)

DELLA-BIANCA, LINO, and OLSON, D. F., Jr.
Soil-site studies in Piedmont hardwood and pine-hardwood upland forests. Forest Sci. 7: 320-329, illus.
(Procedures used for soil-site investigations in subclimax softwood types did not produce useful guides for climax forests in the Piedmont although a number of the measured soil factors were correlated with tree growth.)

DIXON, J. C.
Pine chafer beetle causes damage in the Southeast. Southeast. Forest Expt. Sta. Res. Notes 156, 2 pp.
(Since 1956 this beetle has been reported attacking planted pine in the southeastern United States.)

DIXON, J. C., and OSGOOD, E. A.
Southern pine beetle — a review of present knowledge. Southeast. Forest Expt. Sta. Paper 128, 34 pp., illus.
(Literature on the southern pine beetle is reviewed and research findings are summarized.)

DORMAN, K. W.
Selection as a method of tree breeding. Sixth South. Conf. on Forest Tree Improvement Proc. 1961: 65-72.
(The large amount of inherent variation that apparently occurs in southern tree species should be fully utilized in tree breeding before much work is done with other methods.)

DROOZ, A. T.
Mesoleius tenthredinis Morl. in Pennsylvania and Michigan. Canad. Ent. 93: 804-807.
(Parasite egg encapsulation was found in host *Pristiphora erichsonii* from lower Michigan. Percent parasitism increased in Pennsylvania until 1960 when a serious decline began.)

DROOZ, A. T., and SOLOMON, J. D.
Elm spanworm egg mass studies. Jour. Econ. Ent. 54: 1060-1061, illus.
(The elm spanworm oviposits significantly more egg masses on red or white oaks than on hickories. The third- and fourth-foot sections of 5-foot branch samples contained three-fifths of the masses.)

DROOZ, A. T., and SOLOMON, J. D.
Southeast. *In* Forest insect conditions in the United States 1960. Forest Serv., U. S. Dept. Agr., pp. 30-32, illus.
(Reports important insect outbreaks in forests in the Southeast during 1960.)

EBEL, B. H.
Thrips injure slash pine female flowers. Jour. Forestry 59: 374-375, illus.
(Damage to cones and seed of slash and longleaf pine, formerly ascribed to various causes, caused by thrips.)

EVANS, T. C., BARBER, J. C., and SQUILLACE, A. E.
Some statistical aspects of progeny testing. Sixth South. Conf. on Forest Tree Improvement Proc. 1961: 73-79.
(In 10-year-old slash pine, coefficients of variation tend to become stable at about 20 trees per plot for height, diameter, bark thickness, and clear length.)

FONS, W. L.
Rate of combustion from free surfaces of liquid hydrocarbons. Combustion and Flame 5(3): 283-287, illus.
(Burning velocity of n-hexane and cyclohexane as related to the area of the burning fuel surface was studied.)

FONS, W. L., BRUCE, H. D., and PONG, W. Y.
A steady-state technique for studying the properties of free-burning wood fires. Natl. Acad. Sci. Natl. Res. Council Pub. 786: 219-234, illus.
(Describes and illustrates a steady-state model for studying effect of fuel and fuel bed variables on fire behavior of wood fires burning in an unconfined atmosphere.)

FOSTER, A. A.
Control of black root rot of pine seedlings by soil fumigation in the nursery. Ga. Forest Res. Council Rpt. 8, 5 pp., illus.
(Fumigation of pine nursery soils with methyl bromide controlled black root rot and increased nursery production.)

FOSTER, A. A., and KRUEGER, D. W.
Protection of pine seed orchards and nurseries from fusiform rust by timing ferbam sprays to coincide with infection periods. Ga. Forest Res. Paper 1, 4 pp., illus.
(Instructions for timing sprays to reduce costs while maintaining effective protection.)

GABY, L. I.
Forced air-drying of southern pine lumber. Southeast. Forest Expt. Sta. Paper 121, 20 pp., illus.
(4/4 pine can be dried to 19 percent moisture content in 4 to 6 days with very little degrade if minimum temperatures, EMC conditions, air velocities, and length of air travel are controlled.)

HAMILTON, J. R., and BETHEL, J. S.
A photo-optical method for determining gross characteristics of wood. Jour. Forestry 59: 373-374, illus.
(Describes a method of quantitatively comparing superficial visual characteristics of wood, such as annual increment width, width of latewood, or relative proportions of tissues in latewood of hardwoods.)

HANEY, G. P.
The back-pack mist blower. Forest Farmer 20(13): 8, 14, 16, illus.
(Based on tests in Piedmont Virginia, portable back-pack mist blowers offer new possibilities for low-cost hardwood control on small holdings.)

HARMS, W. R.
Growth of fusiform cankers on young slash pine. Southeast. Forest Expt. Sta. Res. Notes 159, 2 pp.
(If a slash pine is to be kept in the stand for any length of time, it should be pruned of rust cankers closer than 14 inches to the stem.)

HEFNER, J. E., and STOREY, T. G.
An analysis of 1959 forest fires and fire danger in Georgia. Ga. Forest Res. Paper 2, 38 pp., illus.
(Statistics of actual fires and burning conditions in the State.)

HEFNER, J. E., and STOREY, T. G.
An analysis of 1960 forest fires and fire danger in Georgia. Ga. Forest Res. Paper 7, 40 pp., illus.
(Substantiates first-year study results and demonstrates uses of danger rating trends for evaluating accomplishments in prevention and fire control.)

HEPTING, G. H.
Pinus radiata susceptible to pitch canker. Plant Dis. Rptr. 45(11): 889-890.
(*Pinus radiata* was demonstrated to be highly susceptible to the pitch canker fungus. Fruiting of the fungus was also noted on this host.)

HEPTING, G. H.
The 10 most important forest pests in the South — insects and diseases. Forest Farmer 21(1): 11, 30-31.
(Major forest tree diseases in the South are discussed.)

HEPTING, G. H., and BERRY, C. R.
Differentiating needle blights of white pine in the interpretation of fume damage. Internatl. Jour. Air and Water Pollut. 4 (½): 101-105.
(Five needle blights of white pine are distinguished on the basis of symptomatology.)

HEWLETT, J. D.
Response of fescue to natural moisture gradient on an artificial slope. Southeast. Forest Expt. Sta. Res. Notes 152, 2 pp.
(Minor changes in soil moisture stress may in part account for observed reductions in form and vigor of plants with increasing elevation on well-watered natural slopes.)

HEWLETT, J. D.
Soil moisture as a source of base flow from steep mountain watersheds. Southeast. Forest Expt. Sta. Paper 132, 11 pp., illus.
(Model studies of unsaturated flow in sloping soil columns show that ground water is not the only source of base flow in mountain streams.)

HEWLETT, J. D., and DOUGLASS, J. E.
A method for calculating error of soil moisture volumes in gravimetric sampling. Forest Sci. 7: 265-272, illus.
(Limitations in sampling soil density and moisture percent to determine inches of water renders the gravimetric method a poor tool for hydrologic research.)

HEWLETT, J. D., and HIBBERT, A. R.
Increases in water yield after several types of forest cutting. Bul. Internatl. Assoc. Sci. Hydrol. 6(3): 5-17, illus.
(Effects of timber and brush removal on water yields from small watersheds are examined in the light of 25 years of hydrologic research at Coweeta.)

HODGES, C. S.
Freezing lowers survival of three species of southern pines. Tree Planters' Notes 47: 23-24.
(Prolonged periods of freezing seriously lowered survival of three southern pine species, with longleaf pine most sensitive to this type of injury.)

HODGES, C. S.
New hosts for Cercospora thujina Plakidas. Plant Dis. Rptr. 45(9): 745.
(Four new host species are reported as being attacked by *Cercospora thujina*.)

HODGES, C. S., and GREEN, H. J.
Survival in the plantation of eastern redcedar seedlings infected with Phomopsis blight in the nursery. Plant Dis. Rptr. 45(2): 134-136.
(Relatively little Phomopsis blight infection at the time of planting resulted in high mortality of the seedlings after two growing seasons.)

HOEKSTRA, P. E.
Research helps build better forestry in Virginia. Forest Farmer 20(8): 12-13, 22, illus.
(Current research programs of federal, state, and private agencies in Virginia.)

HOEKSTRA, P. E.
Tree-raising succeeds on barren sand tracts. Tree Planters' Notes 48: 11-12, illus.
(Describes successful planting methods on dune-like sands near Jacksonville, Florida.)

HOEKSTRA, P. E., MERKEL, E. P., & POWERS, H. R., JR.
Production of seeds of forest trees. U. S. Dept. Agr. Yearbook 1961: 227-232.
(Current status of research and action programs and problems concerned with forest tree seed production.)

HUPPUCH, C. D.
Epicormic branching on sycamore. Southeast. Forest Expt. Sta. Res. Notes 166, 1 p.
(Dense stands of sycamore can be thinned to residual densities as low as 80 square feet of basal area per acre without appreciable epicormic branching.)

JOHNSON, F. M.
Count down on deer. Wildlife of North Carolina 25(8): 8-9.
(Lists cooperative wildlife projects carried on by U. S. Fish and Wildlife Service, U. S. Forest Service, military organizations, and state game agencies, and describes some wildlife census techniques.)

JONES, E. P., JR.
Gum yields of planted slash pine. AT-FA Jour. 23(7): 9-10. Also in Naval Stores Rev. 71(2): 4-5, 19.
(Over a 3-year period a 17-year-old plantation produced gum yields comparable to wild stands with similar trees.)

JONES, E. P., JR.
Wide spacing of slash pine produces early gum and sawtimber yields. Southeast. Forest Expt. Sta. Res. Notes 169, 2 pp.
(Gross annual returns per acre per year were almost $19.00 for a 26-year-old stand planted at 15x15 feet in middle Georgia.)

JONES, LEROY
Effect of light on germination of forest tree seed. Internatl. Seed Testing Assoc. Proc. 26(3): 437-452.
(Reports response of various species of forest tree seed to light, as well as work on length of photoperiod, intensity, and wave length.)

KLAWITTER, R. A.
Seedling size affects early survival and height growth of planted cypress. Southeast. Forest Expt. Sta. Res. Notes 155, 2 pp.
(Good survival and growth can be expected on first bottom sites with 1-0 cypress seedlings with stem diameters 0.25 inch and larger at the root collar.)

KLAWITTER, R. A., and STUBBS, JACK
A reliable oak seed trap. Jour. Forestry 59: 291-292, illus.
(Specifications and sketches for constructing a paperboard seed trap for trapping acorns.)

KORMANIK, P. P., HANEY, G. P., and DORMAN, K. W.
Loblolly pine of northern provenance may be best for planting in Virginia. Southeast. Forest Expt. Sta. Res. Notes 157, 2 pp.
(After 15 years, height of loblolly pine of North Carolina origin was greater than for stock from South Carolina, Mississippi, and Arkansas stocks. Stem form was very poor and only a small number would make good quality trees.)

KOWAL, R. J.
Control of insects affecting shade trees and small woodlands. Pest Control 29(10): 9-10, 12-13, 16, 77-78, 80, illus.
(Many pest control operators are trained and equipped to control shade tree insects. General problems of control are discussed.)

KOWAL, R. J.
The future of insect control. Forest Farmer 21(1): 17, illus.
(New methods of insect control are being developed. These, plus improved chemical and natural methods, promise forest insect control in the future.)

KRAUS, J. F., and THOMAS, L. T.
Results of trials of modified acrylic polymers in grafting slash pine. Jour. Forestry 59: 451.
(When tested on graft scions from trees 11 to 37 years old, it was found that TAT P. T. A. is a suitable substitute for grafting wax; TAT LOK seriously depressed graft survival.)

KRUEGER, D. W.
Threshold values of relative humidity for large fires in Georgia. Ga. Forest Res. Paper 3, 5 pp., illus.
(77 percent of the large fires occurred on days with relative humidity of 25 percent or less.)

KRUEGER, D. W., and PACHENCE, A. M.
Wind directions for prescribed burning in southeastern United States. Southeast. Forest Expt. Sta. Paper 131, 29 pp., illus.
(Westerly winds are more persistent than other directions at stations studied. Windroses show detailed wind persistency values for stations by months.)

LANGDON, O. G.
Yield of unmanaged slash pine stands in south Florida. Southeast. Forest Expt. Sta. Paper 123, 13 pp., illus.
(Cubic-foot volume and yield tables for slash pine stands in south Florida.)

LARSON, R. W., and GOFORTH, M. H.
Florida's timber. Southeast. Forest Expt. Sta. Forest Survey Release 57, 32 pp., illus.
(In the 24 years between the first and third surveys in Florida, forest land area decreased 11 percent. Total pine volume remained about the same, but pine sawtimber decreased 16 percent.)

LARSON, R. W., NICHOLS, A. C., and GOFORTH, M. H.
Pine volume moves up in southeast. Forest Farmer 21(3): 14-15.
(Comparisons between periodic surveys in the Southeast show that forest area is continuing to increase. Total pine volume is increasing slightly, but pine sawtimber volume continues to decrease.)

LARSON, R. W., NICHOLS, A. C., and GOFORTH, M. H.
Timber trends in the southeast. Southeast. Forest Expt. Sta. Forest Survey Release 58, 16 pp., illus.
(Recent Forest Surveys show that the Southeast has slightly more forest area and total pine volume now than 10 years ago, but slightly less pine sawtimber.)

LOTTI, THOMAS
The case for natural regeneration. *In* Advances in Southern Pine Management. Tenth Ann. Forestry Symposium Proc., La. State Univ. School Forestry 1961: 16-25.
(Annual seed production, seedling crops, and seedbed preparation in sawtimber stands of loblolly pine in the coastal plain and how these fit into a new regeneration technique called seed-in-place or seedlings-in-place.)

McALPINE, R. G.
Hypoxylon tinctor associated with a canker on American sycamore trees in Georgia. Plant Dis. Rptr. 45(3): 196-198.
(Serious cankers developed on sycamores following a rather heavy thinning in a small bottomland stand.)

McALPINE, R. G.
Yellow-poplar seedlings intolerant to flooding. Jour. Forestry 59: 566-568.
(Yellow-poplar seedlings were not affected by dormant season flooding, but mortality occurred after 4 days of flooding in May and after 3 days in June. All seedlings were killed after 2 weeks of flooding during the growing season.)

McALPINE, R. G., and REINES, MERVIN
Photomicrographs by direct projection. Jour. Forestry 59: 771-772, illus.
(Techniques for using a microscope as a photographic enlarger to project the slide image directly to print paper.)

McGEE, C. E.
Age of stock as a factor in survival and growth of longleaf seedlings. Southeast. Forest Expt. Sta. Res. Notes 158, 2 pp.
(Planting large seedlings does not necessarily insure good survival and rapid height growth.)

McGEE, C. E.
Soil-site index for Georgia slash pine. Southeast. Forest Expt. Sta. Paper 119, 9 pp., illus.
(Site quality increases as thickness of A_1 horizon increases. Optimum height growth was found on sites with depth to a fine-textured horizon of 28 to 30 inches.)

McGREGOR, W. H. D., ALLEN, R. M., and KRAMER, P. J.
The effect of photoperiod on growth, photosynthesis, and respiration of loblolly pine seedlings from two geographic sources. Forest Sci. 7: 342-348.
(Absolute and relative growth of long-day (15 hours) seedlings was greater than that of short-day (9.5 hours) seedlings. Photoperiod had no significant effect on rate of respiration.)

MARTIN, R. E., and DAVIS, L. S.
Temperatures near the ground during prescribed burning. Papers of the Mich. Acad. Sci. Arts, and Letters, Vol. XLVI, 1961 (1960 meeting).
(Time-temperature curves for prescribed fires in Michigan jack pine slash and Georgia palmetto-gallberry fuel. Head fires produced highest temperatures and rates of heat yield.)

MATTHEWS, F. R.
Fomes annosus root rot — an increasing threat to southern pines. The Unit 90: 13-14.
(Outlines current status of annosus root rot in southern pine plantations and possible measures of control.)

MERKEL, E. P.
A study of losses in the 1960 slash pine cone crop. Southeast. Forest Expt. Sta. Res. Notes 164, 2 pp.
(An enumeration of the causes of seed losses on seven trees between the post-flowering and cone-maturation period.)

MERKEL, E. P., and EBEL, B. H.
Cone and seed insects and their control. Sixth South. Conf. on Forest Tree Impr. Proc. 1961: 137-138.
(Discusses general biology of the most important cone and seed insects that attack slash pine and results of control studies.)

METZ, L. J., LOTTI, THOMAS, and KLAWITTER, R. A.
Some effects of prescribed burning on coastal plain forest soil. Southeast. Forest Expt. Sta. Paper 133, 10 pp., illus.
(Annual and periodic fires over a 10-year period had no significant influence on the physical properties of the soil.)

NELSON, R. M.
Burning index as a partial guide to air patrol in the South. Southeast. Forest Expt. Sta. Paper 118, 11 pp., illus.
(A basis for timing air patrol for maximum effectiveness and economy.)

NELSON, R. M.
Some applications of danger ratings in forest fire control and management. Southeast. Forest Expt. Sta. Paper 129, 26 pp., illus.
(Describes major uses of fire danger ratings and presents methods of analyzing fire and fire danger records.)

NELSON, T. C.
Loblolly pine growth as related to site, age, and stand density. Soc. Amer. Foresters Proc. 1960: 12-14.
(Merchantable cubic-foot growth phase of two studies involving loblolly pine growth in relation to site, age, and stand density in natural stands.)

NELSON, T. C.
Silvical characteristics of pignut hickory. Southeast. Forest Expt. Sta. Paper 137, 10 pp., illus.
(Extent and climate of botanical range, edaphic and physiographic site conditions, reproductive and growth habits, ecology, plant and animal pests, and response to management.)

NELSON, T. C.
Silvical characteristics of shagbark hickory. Southeast. Forest Expt. Sta. Paper 135, 11 pp., illus.
(Extent and climate of botanical range, edaphic and physiographic site conditions, reproductive and growth habits, ecology, plant and animal pests, and response to management.)

NELSON, T. C., CLUTTER, J. L., and CHAIKEN, L. E.
Yield of Virginia pine. Southeast. Forest Expt. Sta. Paper 124, 11 pp., illus.
(Cubic-foot volume and yield tables for Virginia pine in the Piedmont.)

NELSON, T. C., LOTTI, THOMAS, BRENDER, E. V., and TROUSDELL, K. B.
Merchantable cubic-foot volume growth in natural loblolly pine stands. Southeast. Forest Expt. Sta. Paper 127, 12 pp., illus.
(Cubic-foot growth of natural loblolly pine as related to age, site, stand density, and site-stand density interaction in thinned and unthinned stands.)

PAGE, R. H.
Preservatives and turpentined utility poles. Forest Farmer 20(6): 11-12, 14, illus.
(Seasoned and steam-conditioned slash pine poles treated satisfactorily behind the scar faces; treatment of turpentined longleaf pine poles was erratic.)

PAGE, R. H.
Weight as a measure of volume for southern yellow pine timber. Forest Prod. Jour. 11(7): 300-302, illus.
(The prediction of volume of standing trees by weight would probably be no more accurate than the present method of predicting volume from diameter and merchantable length.)

PAGE, R. H., and BOIS, P. J.
Buying and selling southern yellow pine saw logs by weight. Ga. Forest Res. Council Rpt. 7, 8 pp., illus.
(For pine saw logs in Georgia, weight gives an accurate measure of cubic-foot volume and, within wider limits, a measure of board-foot volume.)

POWERS, H. R., JR., and BOYCE, J. S., JR.
Fomes annosus on slash pine in the Southeast. Plant Dis. Rptr. 45 (4): 306-307.
(Annosus root rot was found most severe in thinned slash pine plantations; unthinned plantations, and natural stands in general, had less damage.)

RENSHAW, J. F.
Silvical characteristics of white basswood. Southeast. Forest Expt. Sta. Paper 136, 7 pp., illus.
(Extent and climate of botanical range, edaphic and physiographic site conditions, reproductive and growth habits, ecology, plant and animal pests, and response to management.)

RIPLEY, T. H., and McGINNES, B. D.
Hunting and fishing recreation on Virginia's national forests. Va. Wildlife 22(10): 4-5.
(Discusses hunting and fishing on national forests of Virginia and reports, in popular form, pressure, kill, and game population-density relationship.)

ROBINSON, V. L.
Pulpwood price trends in the Southeast. Southeast. Forest Expt. Sta. Res. Notes 163, 2 pp.
(The 1960 all-wood prices were $16.45 per cord for rough pine pulpwood and $13.60 per cord for hardwood. The most commonly reported price for pine chips was $6.50 per ton.)

ROMANCIER, R. M.
Weight and volume of plantation-grown loblolly pine. Southeast. Forest Expt. Sta. Res. Notes 161, 2 pp.
(Weight and volume of wood and bark by diameter and total height to top diameters of 3.6 inches and 2.0 inches inside bark.)

ROWAN, S. J.
The effectiveness of Eptam in controlling weeds in southern forest nurseries. Tree Planters' Notes 48: 29-32.
(Four months of excellent weed control was obtained by using a combination of Eptam and mineral spirits; however, some stunting of pine seedlings was noted.)

ROWAN, S. J., and GOOD, J. M.
The efficacy of postplanting applications of DBCP for control of Tylenchorhynchus claytoni in southern forest nurseries. (Abs.) Phytopathology 51(9): 645.
(Several dosage rates of DBCP were evaluated for nematode control in both spring and fall applications.)

RUCKER, T. W., and SMITH, W. R.
Forced-air drying of lumber — research and experimental. Forest Prod. Jour. 11(9): 390-394, illus.
(Comparative results of drying magnolia in a commercial forced air-dryer and drying poplar in an experimental forced air-dryer.)

RUDOLF, P. O., CRITCHFIELD, W. B., HITT, R. G., ORR-EWING, ALLAN, and SQUILLACE, A. E.
Society of American Foresters report on a study of seed certification conducted by the committee on forest tree improvement. Jour. Forestry 59: 656-661.
(Ninety-six replies to a questionnaire show opinions on need for and type of seed certification suitable to forest tree seed and how certification should be administered.)

SAUCIER, J. R., and MILLER, R. L.
Deterioration of southern pine chips during summer and winter storage. Forest Prod. Jour. 11(8): 371-379, illus.
(Deterioration of chips in the open did not exceed deterioration of roundwood; outside pine chip storage in the South appears practical.)

SCHULTZ, A. J.
A second report on interplanted slash pine. Southeast. Forest Expt. Sta. Res. Notes 154, 2 pp.
(Average tree size and volume production from interplants was smaller than from original planting and were judged failures.)

SLUDER, E. R.
Exploratory studies on chemical control of unwanted hardwoods in the southern Appalachians. Southeast. Forest Expt. Sta. Res. Notes 165, 2 pp.
(Rhododendron, laurel, and sourwood sprouted profusely after being topkilled by sodium arsensite applied with a tree injector. Rhododendron sprouts can be controlled by spraying cut stumps with 2, 4, 5-T in oil.)

SLUDER, E. R., OLSON, D. F., JR., and JARRETT, T. W.
Tests on direct seeding of oak in the Piedmont and southern Appalachians of North Carolina. Southeast. Forest Expt. Sta. Paper 134, 12 pp., illus.
(White, northern red, and black oak acorns can be direct seeded in spring or fall if treated for weevil control and planted 1 to 2 inches deep in mineral soil.)

SMITH, W. R.
Building homes to withstand hurricane damage. Forest Prod. Jour. 11(4): 176-177, illus.
(When properly used, wood is the best material known for the construction of homes in hurricane and other storm areas.)

SMITH, W. R.
Is forced air-drying a part of your future? South. Lumberman 203 (2537): 131-133, illus.
(Research results on forced air-drying by the Southeastern Forest Experiment Station.)

SMITH, W. R.
The structure and properties of wood as related to utility poles. South. Atlantic Wood Pole Conf. Proc. 1961: 11-18.
(Wood characteristics and properties directly related to utilization of wood for poles, with special reference to southern pine.)

SMITH, W. R.
Wood seasoning. Indus. Woodworking 13(9): 14-15.
(Some basic concepts in moisture control in wood during seasoning.)

SPEERS, C. F., and SCHMIEGE, D. C.
White grubs in forest tree nurseries and plantations. U. S. Dept. Agr. Forest Pest Leaflet 63, 4 pp., illus.
(Distribution, hosts, evidence of attack, description of stages, life history, habits, and control.)

SQUILLACE, A. E., and BENGTSON, G. W.
Inheritance of gum yield and other characteristics of slash pine. Sixth South. Conf. on Forest Tree Impr. Proc. 1961: 85-96.
(For 15-year-old plantation trees, heritability percents as determined by components of variance methods for traits in cross- and wind-pollinated progenies were calculated.)

SQUILLACE, A. E., and DORMAN, K. W.
Selective breeding of slash pine for high oleoresin yield and other characters. *In* Recent Advances in Botany, Section IV: 1616-1621. Univ. of Toronto, Toronto, Ontario, Canada.
(Eleven-year-old progeny were "micro-chipped" and yields of gum were related to parent gum-yielding characteristics.)

SWIFT, L. W., JR., and VAN BAVEL, C. H. M.
Mountain topography and solar energy available for evapotranspiration. Jour. Geophys. Res. 66(8): 2565.
(A southern slope in the southern Appalachians may receive twice as much solar radiation in midwinter as a similar northern slope.)

TARAS, M. A.
Circular slide rule for calculating wood moisture content. Southeast. Forest Expt. Sta. Paper 125, 6 pp., illus.
(When green weight and ovendry weight is known, moisture can be read directly from this slide rule.)

VANHAVERBEKE, D. F., and BARBER, J. C.
Less growth and no increased flowering from changing slash pine branch angle. Southeast. Forest Expt. Sta. Res. Notes 167, 2 pp.
(No increase in flowering was noted from changing branch angle. Branch elongation decreased as branch angle increased.)

VIMMERSTEDT, J. P.
Cubic-foot volume tables for southern Appalachian white pine plantations. Southeast. Forest Expt. Sta. Res. Notes 162, 2 pp.
(Cubic-foot volumes inside bark and outside bark by diameter and total height to 3.0 and 4.0 inches top diameter outside bark.)

WELLS, C. G.
Underplanting tests in pine stands. Southeast. Forest Expt. Sta. Res. Notes 160, 2 pp.
(Underplanting yellow-poplar, northern red oak, and green ash was successful in 19-year-old loblolly pine plantation, but eastern redcedar planting was unsuccessful.)

WENGER, K. F.
Some aspects of combining naval stores production and timber growing. The Unit 90: 15-16.
(Short-term methods of gum extraction in which trees are worked intensively fit well in timber management plans.)

WHITEHEAD, T. H., and SHERRILL, R. W.
Wood charcoal from a cinder block kiln: a physico-chemical study. Forest Prod. Jour. 11(8): 336-339, illus.
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